Endangered Species Act - Section 7 Consultation

# BIOLOGICAL OPINION

U.S. Fish and Wildlife Service Reference:
13410-2008-F-0383

## South Park Bridge Replacement

## King County, Washington

Agency:

Federal Highway Administration, Washington Division
Olympia, Washington

Consultation Conducted By:

U.S. Fish and Wildlife Service
Washington Fish and Wildlife Office
Lacey, Washington

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Washington Fish and Wildlife Office

8/17/09
Date

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## LIST OF ACRONYMS

| | |
|---|---|
| Act | Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) |
| BA | Biological Assessment |
| BMP | Best Management Practice |
| Corps | U.S. Army Corps of Engineers |
| CSL | Clean-Up Screening Level |
| Cu | Copper |
| cy | Cubic Yard |
| DMMP | Dredged Material Management Program |
| EAA | Early Action Area |
| EPA | U.S. Environmental Protection Agency |
| FHWA | Federal Highway Administration |
| FMO | Foraging, Migration, and Overwintering |
| FWS | U.S. Fish and Wildlife Service |
| HQ | Hazard Quotient |
| KCDOT | King County Department of Transportation |
| LDWG | Lower Duwamish Waterway Group |
| MHHW | Mean-Higher High Water |
| MTCA | Model Toxics Control Act |
| NTU | Nephelometric Turbidity Unit |
| Opinion | Biological Opinion |
| PAH | Polycyclic Aromatic Hydrocarbon |
| PCB | Polychlorinated Biphenyl (PCB) |
| PCE | Primary Constituent Element |
| PEL | Probable Effect Level |
| PGIS | Pollution-Generating Impervious Surface |
| RPM | Reasonable and Prudent Measure |
| SEL | Sound Exposure Level |
| SEV | Severity-of-Effect |
| SPCC | Spill Prevention Control and Countermeasures |
| SPL | Sound Pressure Level |
| SQG | Sediment Quality Guideline |
| SQS | Sediment Quality Standard |
| TEL | Threshold Effect Level |
| TL | Transmission Loss |
| TRV | Toxicity Reference Value |
| TSS | Total Suspended Solids |
| TTS | Temporary Threshold Shift |
| WDOE | Washington State Department of Ecology |
| WRIA | Water Resources Inventory Area |
| WSDOT-H&LP | Washington State Department of Transportation, Highways & Local Programs |
| Zn | Zinc |

## CONSULTATION HISTORY

The Road Services Division of the King County Department of Transportation (KCDOT), Highways and Local Programs Division of the Washington State Department of Transportation (WSDOT-H&LP), and Washington Division of the Federal Highway Administration (FHWA), propose to construct a new South Park Bridge over the lower Duwamish River in unincorporated King County, Washington. The project will be paid for in-part with federal funds and may also require a Clean Water Act section 404 permit. Federal funding and issuance of a section 404 permit establishes a nexus requiring consultation under section 7(a)(2) of the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) (Act).

The U.S. Fish and Wildlife Service (FWS) based this Biological Opinion (Opinion) on the following sources of information: the Biological Assessment (BA), dated March 2008 and received on June 5, 2008; a BA Addendum and response to FWS questions and comments (Addendum), dated February 11, 2009, and received on February 27, 2009; email correspondence (and attachments) dated April 8 and April 20, 2009; a field review of the project site (April 22 and 29, 2009); and, various scientific literature and personal communications cited herein. A complete record of this consultation is on file at the Washington Fish and Wildlife Office in Lacey, Washington.

The following timeline summarizes the history of this consultation:

June 5, 2008 – The FHWA submits a BA and request for formal consultation with an effect determination of "may affect, likely to adversely affect" for bull trout (*Salvelinus confluentus*) and designated bull trout critical habitat.

August 27, 2008 – The FWS requests additional information regarding the design and potential temporary and permanent effects relevant to the effect determination for bull trout and designated bull trout critical habitat.

October 2, 2008 – The FWS attends a meeting with the FHWA, WSDOT-H&LP, KCDOT, and consultant staff to discuss design changes and the request for additional information dated August 27.

February 12, 2009 – The FWS receives an electronic copy of the Addendum (including attachments) from WSDOT-H&LP via email.

February 27, 2009 – The FWS receives a hardcopy of the Addendum (dated February 11, 2009) from FHWA and initiates formal consultation.

April 8 and 20, 2009 – The FWS receives emails providing additional information regarding site contamination and proposed pile driving operations.

April 22 and 29, 2009 – The FWS visits the project site to review conditions in the field.

## BIOLOGICAL OPINION

### DESCRIPTION OF THE PROPOSED ACTION

The KCDOT, WSDOT-H&LP, and FHWA propose to construct a new South Park Bridge over the lower Duwamish River in unincorporated King County, Washington (Figure 1). The existing South Park Bridge, located along 16th Avenue South and at approximate river mile 4.0, is structurally deficient and vulnerable to seismic instability. The proposed project will demolish the existing bridge once the new bridge has been constructed. The project limits are adjacent to both the City of Seattle and the City of Tukwila in Township 24 North, Range 4 East, Section 32. The project is located within Water Resources Inventory Area (WRIA) 9 – Duwamish-Green, hydraulic unit code 17110013 (Duwamish River).

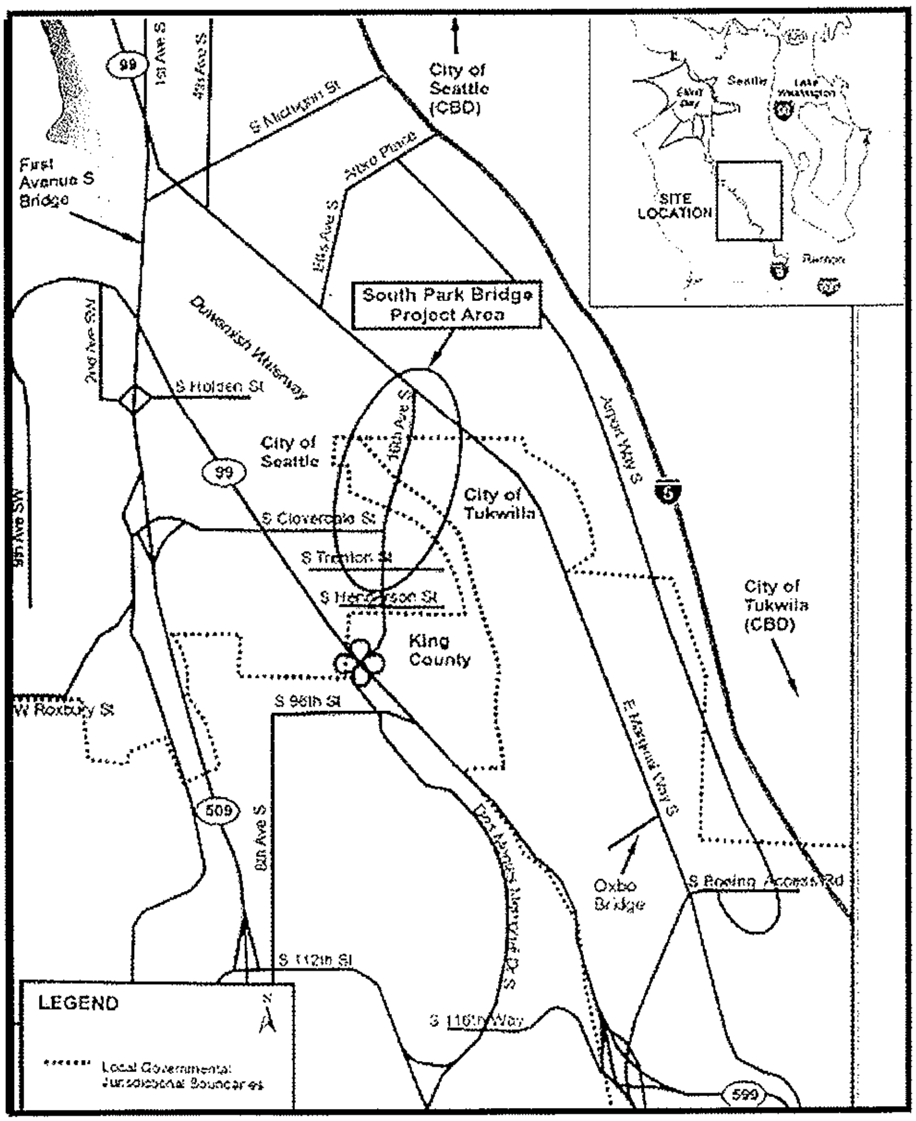



Figure 1 Vicinity map.

Design Elements and Items of Work

The proposed project will construct a new 5-span, movable center span, bascule bridge to the northwest (downstream) of the existing bridge. The new bridge, approximately 920 ft in total length, will span more than 400 ft of the Duwamish River (including a slightly widened 125 ft center navigation channel), with two permanent caisson foundations and bascule piers located below the Mean-Higher High Water (MHHW) line. The new bridge abutments, and piers 2 and 5, will be located above MHHW with foundations supported on drilled shafts (Figure 2).

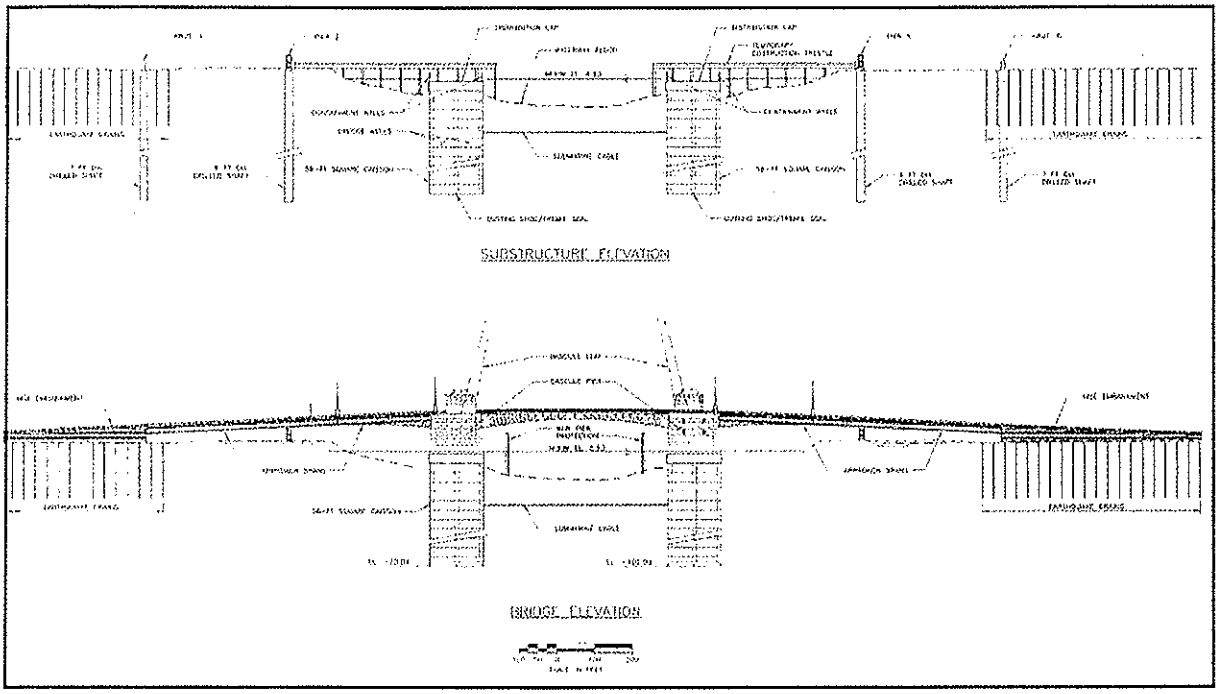


Figure 2 Bridge piers and superstructure.

The new bridge will have 58-foot square concrete caisson foundations (3,364 $ft^2$ each, and 6,728 $ft^2$ in total below MHHW), located approximately 20 feet closer to the shoreline than the existing bridge pier foundations. Construction of the cast-in-place north/south caisson foundations and bascule piers, demolition of the existing bascule piers, removal/deconstruction of the existing pier protection ("fender") piles, and placement of the new pier protection piles will be completed over three in-water work windows/seasons (Table 1). This work will require two sets of temporary work trestles; the first set (stage 1- "construction") will be used to gain access to the new caisson foundations and bascule piers; the second set (stage 2 – "demolition") will be used to gain access to the existing bascule piers. In addition to temporary work trestles, the project will use steel sheet pile cofferdams and barges or modular barges ("floating platforms") to stage and complete work below MHHW and/or directly above the Duwamish River. Much of the bridge superstructure will be fabricated off-site, including the movable center span steel support members and modular deck, and the approach span pre-cast concrete girders.

Table 1 Expected in-water work by season.

| | |
|---|---|
| **Season 1**<br>August 1, 2009 to February 15, 2010 | Test pile program. |
| **Season 2**<br>August 1, 2010 to February 15, 2011 | Construct (stage 1- "construction") temporary work trestles and new north/south bascule pier foundations. |
| **Season 3**<br>August 1, 2011 to February 15, 2012 | Deconstruct/remove temporary work trestles and existing pier protection/fender piles; construct (stage 2 – "demolition") temporary work trestles and cofferdams. |
| **Season 4**<br>August 1, 2012 to February 15, 2013* | Construct new pier protection/fender piles; deconstruct/remove temporary work trestles and cofferdams. |

* The tentative schedule for construction indicates Season 4 in-water work will be complete by late October 2012.

Other design elements and items of work include, but are not limited to the following: 1) on-site staging, 2) demolition of buildings and structures, and relocation of utilities, 3) establishment of temporary construction access, 4) placement of compaction grouting to improve subsurface soil stability, 5) installation of "earthquake drains" at the new bridge abutments to mitigate soil liquefaction, 6) placement of fill and construction of bridge approach retaining walls, 7) realignment (reconstruction) and other minor improvements to the local street network, 8) bridge deck construction, paving, and striping, 9) drainage improvements, 10) construction of stormwater facilities to treat runoff from new and existing pollution-generating impervious surface (PGIS), 11) directional boring and placement of a sub-marine cable between the new bascule piers, and 12) on-site restoration and enhancement. Prior to the first season of construction (i.e., during in-water work Season 1; August 1, 2009 to February 15, 2010) the project will implement a test pile program to evaluate in-water construction methods and support other preliminary engineering tasks.

Each of the major design elements are described more completely in the BA and Addendum submitted by the FHWA (KCDOT 2008, 2009). Those descriptions are incorporated here by reference, except where they have been revised or amended as agreed to during the course of consultation and documented in correspondence between the FHWA and the FWS. The proposed project is scheduled for construction over a 34-month period (April 2010 – March 2013). All work below MHHW of the lower Duwamish River will be completed during an in-water work window of August 1 to February 15.

<u>In-Water Work</u>

Construction of the new caisson foundations, bascule piers, and pier protection piles, and demolition and removal of the existing piers and protection piles will be completed over three in-water work windows/seasons (Table 1). During the in-water work window preceding construction (in-water work Season 1) the project will implement a limited test pile program. The test pile program will place one or two 24-inch diameter steel piles and one or two steel sheet piles while collecting sound pressure level (SPL) and other data needed to evaluate in-water construction methods. The project expects this work will require approximately 5 working days between August 1, 2009 and February 15, 2010 (KCDOT 2009).

In order to complete the proposed in-water work the project will construct two sets of temporary work trestles. The first set of temporary work trestles (stage 1 - "construction"), used to gain access to the locations of the new caisson foundations and bascule piers, will consist of approximately one-hundred seventy 24-inch diameter steel piles, thirty-five16-inch diameter battered ("leaning") steel piles, steel cross bracing/substructure, and decking (Figure 3) (KCDOT 2009). The project will install an additional thirty-two 16-inch diameter steel piles as a template for the placement of two 70-foot square temporary steel sheet pile cofferdams (4,900 $ft^2$ each, and 9,800 $ft^2$ in total).

The second set of temporary work trestles (stage 2 - "demolition"), used to gain access to the locations of the existing bascule piers, will consist of approximately one-hundred forty-five 24-inch diameter steel piles, thirty 16-inch diameter battered steel piles, steel cross bracing/substructure, and decking (KCDOT 2008). The project will install additional 16-inch diameter steel piles as a template for the placement of five temporary steel sheet pile cofferdams (approximately 7,600 $ft^2$ in total), one each for the existing main bascule piers and three intermediate piers.

All piles will be installed with a vibratory hammer, an impact hammer, or a combination, as site conditions allow. Steel sheet piles may be installed by these same methods and/or by direct pushing. Most or all of the load-bearing piles will require proofing with an impact hammer. Except when driving test piles to determine baseline SPLs, the project will conduct all impact pile driving operations with the use of a noise attenuation device (i.e., confined bubble curtain, temporary noise attenuation pile, or functional equivalent). Pile driving equipment, cranes, and other heavy equipment may operate from the temporary work trestles, barges, and/or floating platforms.

Prior to, or during, installation of the trestles/piles or steel sheet pile cofferdams, the project will place a blanket of clean granular material to reduce the amount of sediment that may be re-suspended during the course of pile installation and removal (KCDOT 2008, 2009). A 6 to 12-inch deep sand blanket will be used. The project will place this sand blanket over an area below MHHW as large as 35,000 $ft^2$ (0.8 acre).

The project will remove approximately three-hundred fifty 12-inch diameter creosote-treated wood piles (and dolphins) associated with the existing bridge pier protection system (KCDOT 2008). This material and any other treated wood waste produced by the project will be disposed at a properly permitted disposal site(s). The new permanent bridge pier protection system will consist of approximately one-hundred eighty 24-inch diameter steel piles and fender wales placed

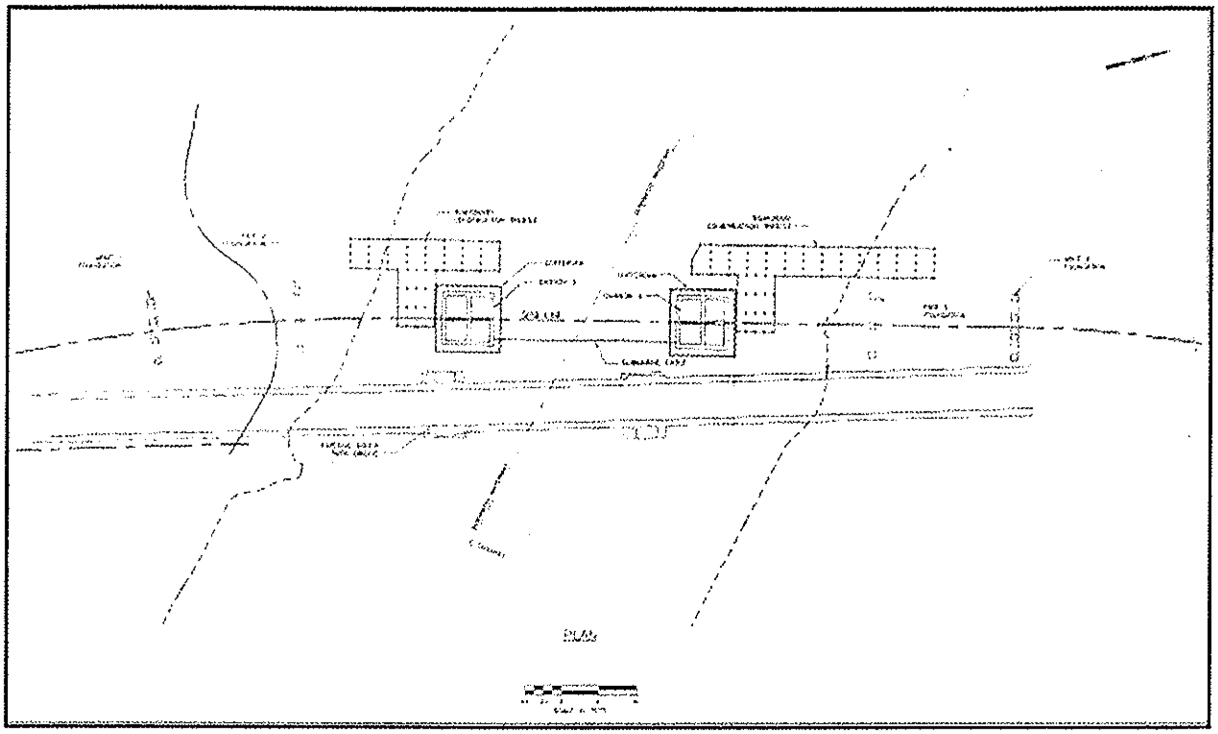


Figure 3 Temporary work trestles and cofferdams for new bascule pier construction.

along the center navigation channel, approximately 295 linear ft to the south and 390 linear ft to the north (KCDOT 2008).

Temporary piles and sheet piles will be removed by direct pulling, extraction with the use of a vibratory hammer, or a combination thereof. If piles break off during extraction, or their removal cannot be achieved by these methods, the project will cut piles off at the mudline or top of the sand blanket (KCDOT 2009).

The project will place approximately 366 temporary steel piles and 179 permanent steel piles (545 steel piles in total) below MHHW (KCDOT 2009). Each set of temporary work trestles, and their associated steel sheet pile cofferdams, will occupy approximately 16,000 $ft^2$ below MHHW for a duration of one year, over two consecutive years (August 2010-11 and August 2011-12). The project does not propose to remove the sand blanket. The FWS expects that this material will be removed at a later date as part of a future clean-up or remedial action conducted within the reach.

The project will construct permanent foundations for the two new bascule piers using a method of construction referred to as a "sand island caisson". Within the two 70-foot square temporary sheet pile cofferdams described above, the project will use a crane-mounted clamshell dredge/bucket (or other similar device) to excavate and remove native substrates to a depth of approximately 30 ft below the bottom of the channel. Within each excavated sheet pile cofferdam the project will place approximately 42 ft of clean granular fill (to +12 ft) and a pre-fabricated 58-foot square caisson "cutting shoe". The full vertical height of each caisson foundation will be constructed as a series of cast-in-place segments, each segment cast and then dredged to sink the foundation to its final depth of approximately -30 ft. Cast-in-place distribution caps and bearing slabs will complete the foundations and precede the largely above-water work necessary to construct the vertical bascule pier walls. A complete description of this work can be found in the Addendum submitted by the FHWA (KCDOT 2009).

Construction of the two permanent caisson foundations will require careful excavation, handling, storage, testing, treatment, transport, and disposal of native substrates, as well as any water that is in-contact with the substrates, known or suspected of contamination. The project will implement a Spill Prevention Control and Countermeasures (SPCC) plan. The SPCC plan will include a description of preexisting contamination and the measures necessary to conduct work without allowing release of materials (WSDOT 2007a; 2008 WSDOT Standard Specification 1-07.15(1)). The project will seal the temporary sheet pile cofferdams so as minimize exchange with the surrounding water column and will partially dewater the cofferdams prior to excavation. The project will pump dewater into holding tanks, and will test and treat this water to ensure any discharge meets all relevant and applicable State surface water quality criteria, and/or allowable limits described in issued wastewater discharge permits (KCDOT 2009). The project may use a variety of best management practices (BMPs) to ensure safe handling, storage, and transport of contaminated or potentially contaminated river sediments and substrate (e.g., spill aprons, drop curtains, gated hoppers operating from fixed locations, sealed containers, etc.). The project will implement approved protocols for waste sampling and characterization (KCDOT 2009). Any characteristically hazardous or toxic waste will be disposed according to all applicable State and federal requirements, at an approved upland disposal site or in-water dredged material disposal site operating under the Dredged Material Management Program (DMMP) (KCDOT 2009, WDNR 2009). The project will implement many or all of these same precautions when completing work within temporary sheet pile cofferdams necessary to demolish and remove the existing main bascule piers and three intermediate piers.

The project will use barges or floating platforms to stage equipment and materials while completing work below MHHW and/or directly above the Duwamish River. The project will use tugs to move and position barges, and adjustable legs will hold barges in-place while completing work. In order to prevent and minimize prop-wash and resulting turbidity, the project will focus barge operations along the Duwamish River's dredged center channel and will only move barges when water depths are sufficient (KCDOT 2009).

The project will complete in-water work necessary to restore and enhance left-bank shallow water, shoreline, and riparian zones in the immediate vicinity of the new bridge. The project will create approximately 6,000 $ft^2$ of tidally-influenced emergent marsh, 2,300 $ft^2$ of shrub-dominated transition zone, and will plant woody riparian vegetation along approximately 240 linear ft of bank (4,300 $ft^2$). These improvements will include removal of existing bank armor and replacement with bioengineered slopes, and placement of large woody debris to enhance shallow water habitat (KCDOT 2009).

The project will comply with all terms and conditions from the Hydraulic Project Approval, Clean Water Act section 404, and shoreline permits issued for the project by the Washington State Department of Fish and Wildlife, U.S. Army Corps of Engineers (Corps), Washington State

Department of Ecology (WDOE), and King County, Washington. The project will comply with the State of Washington's surface water quality standards (WAC 173-201A-200). Any temporary exceedance of the aquatic life turbidity criteria (5 nephelometric turbidity units [NTU] over background when less than 50 NTU; 10 percent increase over background when more than 50 NTU) will not extend more than 300 ft upstream or downstream of construction activities. Water pumped from within sheet pile cofferdams and pilings will be tested and treated as necessary to ensure any discharge meets all relevant and applicable State surface water quality criteria (WAC 173-201A-200, turbidity and pH; WAC 173-201A-260(2)(a), toxics and aesthetics), or allowable limits described in issued wastewater discharge permits.

Proposed Stormwater Design

The proposed project, including realignment/reconstruction and other minor improvements to the local street network, will result in a net reduction of impervious surface (approximately 0.5 acre) and PGIS (approximately 0.1 acre) within the project area (KCDOT 2009). Presently, little or none of the stormwater runoff originating from the existing PGIS (approximately 9.2 acres) is treated prior to discharge. The project proposes basic treatment, using a combination of wet vaults, low-impact development facilities and/or treatment at the West Point Water Treatment Facility, for runoff originating from approximately 3.2 acres of new and existing PGIS within a single threshold discharge area. The proposed stormwater design is expected to achieve measurable reductions in post-project annual stormwater loadings of total suspended solids (TSS), total copper (Cu), and total and dissolved zinc (Zn); no measurable change in dissolved Cu loadings is expected. Table 2 provides a summary of the proposed stormwater design.

Table 2 Stormwater summary (KCDOT 2009).

| **Project Total** | **Existing / Pre-Project Condition** | **Future / Post-Project Condition** | **Net** |
|---|---|---|---|
| Impervious surface (acre). | 9.58 | 9.07 | (0.51) |
| Pollution-generating impervious surface (PGIS; acre). | 9.20 | 9.07 | (0.13) |
| Untreated PGIS (acre). | 9.20 | 5.81 | (3.39) |
| Treated PGIS (acre). | --- | 3.26 | 3.26 |
| Annual pollutant loadings (lb/year)… | | | |
| *Total Suspended Solids* | 5,198 | 5,040 | (158) |
| *Total Zinc* | 10.12 | 9.91 | (0.21) |
| *Dissolved Zinc* | 3.68 | 3.65 | (0.03) |
| *Total Copper* | 1.84 | 1.81 | (0.03) |
| *Dissolved Copper* | 0.49 | 0.49 | --- |

Conservation Measures

The proposed project will implement conservation measures, including but not limited to the following, to further avoid and minimize impacts associated with construction:

- The project will install high-visibility construction fencing to avoid unintended impacts to sensitive areas.
- The project will implement an Engineer-approved SPCC plan to guard against the release of any harmful pollutant or product. A current copy of the approved SPCC plan will be maintained on-site for the duration of the project and no work or staging in advance of work will commence prior to implementing the plan. The approved SPCC plan will provide site- and project-specific details identifying potential sources of pollutants, exposure pathways, spill response protocols, protocols for routine inspection fueling and maintenance of equipment, preventative and protective equipment and materials, and emergency notification and reporting protocols. The SPCC plan will include a description of preexisting contamination and the measures necessary to conduct work without allowing release of materials (WSDOT 2007a; 2008 WSDOT Standard Specification 1-07.15(1)).
- The project will install and maintain appropriate temporary erosion and sediment control BMPs to avoid and minimize affects to waterbodies and wetlands resulting from clearing, grading, management of site drainage and stormwater runoff, and related activities.
- The project will focus barge operations along the Duwamish River's dredged center channel and will only move barges when water depths are sufficient to avoid and minimize prop-wash and resulting turbidity.
- All work below MHHW of the lower Duwamish River will be completed during an in-water work window of August 1 to February 15.
- The project will place an approximately 6- to 12-inch blanket of clean granular material prior to, or during, installation of temporary work trestles/piles and cofferdams to reduce the amount of sediment that may be re-suspended during construction.
- Except when driving test piles to determine baseline SPLs, the project will conduct all impact pile driving operations with the use of a noise attenuation device (i.e., confined bubble curtain, temporary noise attenuation pile, or functional equivalent).
- The project will install and maintain appropriate BMPs to ensure safe handling, storage, and transport of contaminated or potentially contaminated water, river sediments, and substrate. The project will implement Engineer-approved protocols for waste sampling and characterization. Any characteristically hazardous or toxic waste (or wastewater) will be disposed according to all applicable State and Federal requirements, at an approved upland disposal site or at an approved in-water dredged material disposal site operating under the DMMP.

- The project will implement a system or plan to ensure containment of materials, wastes, and debris resulting from bridge construction and demolition. Any treated wood waste produced by the project will be disposed at a properly permitted disposal site(s).
- Any temporary structures placed below MHHW will be removed during the approved in-water work window by direct pulling, extraction with the use of a vibratory hammer, or a combination thereof. If piles break-off during extraction, or their removal cannot be achieved by these methods, the project will cut piles off at the mudline or top of the sand blanket. Any excavation below MHHW will be conducted in isolation from flowing waters.
- Any new or modified stormwater outfalls (and associated bank protection) shall be designed and constructed to prevent bed and bank erosion/scour under foreseeable flows.

Many of the proposed conservation measures are described more completely in the BA and Addendum submitted by the FHWA (KCDOT 2008, 2009). Those descriptions are incorporated here by reference, except where they have been revised or amended as agreed to during the course of consultation and documented in correspondence between the FHWA and the FWS.

## ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

In accordance with policy and regulation, the jeopardy analysis in this Biological Opinion relies on four components: (1) the *Status of the Species*, which evaluates the bull trout's range-wide condition, the factors responsible for that condition, and its survival and recovery needs; (2) the *Environmental Baseline*, which evaluates the condition of the bull trout in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the bull trout; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the bull trout; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the bull trout.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the bull trout's current status, taking into account any cumulative effects, to determine if implementation of the proposed action is likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the bull trout in the wild.

Interim recovery units were defined in the final listing rule for the bull trout for use in completing jeopardy analyses. Pursuant to FWS policy, when an action impairs or precludes the capacity of a recovery unit from providing both the survival and recovery function assigned to it, that action may represent jeopardy to the species. When using this type of analysis, the biological opinion describes how the action affects not only the recovery unit's capability, but the relationship of the recovery unit to both the survival and recovery of the listed species as a whole.

The jeopardy analysis for the bull trout in this Biological Opinion uses the above approach and considers the relationship of the action area and core area (discussed below under the *Status of the Species* section) to the recovery unit and the relationship of the recovery unit to both the survival and recovery of the bull trout as a whole as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the jeopardy determination.

Adverse Modification Determination

This Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statutory provisions of the Act to complete the following analysis with respect to critical habitat.

In accordance with policy and regulation, the adverse modification analysis in this Biological Opinion relies on four components: (1) the *Status of Critical Habitat*, which evaluates the range-wide condition of designated critical habitat for the bull trout in terms of primary constituent elements (PCEs), the factors responsible for that condition, and the intended recovery function of the critical habitat overall; (2) the *Environmental Baseline*, which evaluates the condition of the critical habitat in the action area, the factors responsible for that condition, and the recovery role of the critical habitat in the action area; (3) the *Effects of the Action*, which determines the direct and indirect impacts of the proposed Federal action and the effects of any interrelated or interdependent activities on the PCEs and how that will influence the recovery role of affected critical habitat units; and (4) *Cumulative Effects*, which evaluates the effects of future, non-Federal activities in the action area on the PCEs and how that will influence the recovery role of affected critical habitat units.

For purposes of the adverse modification determination, the effects of the proposed Federal action on bull trout critical habitat are evaluated in the context of the range-wide condition of the critical habitat, taking into account any cumulative effects, to determine if the critical habitat range-wide would remain functional (or would retain the current ability for the polychlorinated biphenyls (PCBs) to be functionally established in areas of currently unsuitable but capable habitat) to serve its intended recovery role for the bull trout.

The analysis in this Opinion places an emphasis on using the intended range-wide recovery function of bull trout critical habitat, especially in terms of maintaining and/or restoring viable core areas, and the role of the action area relative to that intended function as the context for evaluating the significance of the effects of the proposed Federal action, taken together with cumulative effects, for purposes of making the adverse modification determination.

## STATUS OF THE SPECIES (Bull Trout; Coterminous Range)

### Listing Status

The coterminous United States population of the bull trout (*Salvelinus confluentus*) was listed as threatened on November 1, 1999 (64 FR 58910). The threatened bull trout generally occurs in the Klamath River Basin of south-central Oregon; the Jarbidge River in Nevada; the Willamette River Basin in Oregon; Pacific Coast drainages of Washington, including Puget Sound; major rivers in Idaho, Oregon, Washington, and Montana, within the Columbia River Basin; and the St. Mary-Belly River, east of the Continental Divide in northwestern Montana (Cavender 1978; Bond 1992; Brewin and Brewin 1997; Leary and Allendorf 1997).

Throughout its range, the bull trout are threatened by the combined effects of habitat degradation, fragmentation, and alterations associated with dewatering, road construction and maintenance, mining, grazing, the blockage of migratory corridors by dams or other diversion structures, poor water quality, entrainment (a process by which aquatic organisms are pulled through a diversion or other device) into diversion channels, and introduced non-native species (64 FR 58910). Although all salmonids are likely to be affected by climate change, bull trout are especially vulnerable given that spawning and rearing are constrained by their location in upper watersheds and the requirement for cold water temperatures (Battin et al. 2007; Rieman et al. 2007). Poaching and incidental mortality of bull trout during other targeted fisheries are additional threats.

The bull trout was initially listed as three separate Distinct Population Segments (DPSs) (63 FR 31647; 64 FR 17110). The preamble to the final listing rule for the United States coterminous population of the bull trout discusses the consolidation of these DPSs with the Columbia and Klamath population segments into one listed taxon and the application of the jeopardy standard under section 7 of the Act relative to this species (64 FR 58910):

> Although this rule consolidates the five bull trout DPSs into one listed taxon, based on conformance with the DPS policy for purposes of consultation under section 7 of the Act, we intend to retain recognition of each DPS in light of available scientific information relating to their uniqueness and significance. Under this approach, these DPSs will be treated as interim recovery units with respect to application of the jeopardy standard until an approved recovery plan is developed. Formal establishment of bull trout recovery units will occur during the recovery planning process.

### Current Status and Conservation Needs

In recognition of available scientific information relating to their uniqueness and significance, five segments of the coterminous United States population of the bull trout are considered essential to the survival and recovery of this species and are identified as interim recovery units: 1) Jarbidge River, 2) Klamath River, 3) Columbia River, 4) Coastal-Puget Sound, and 5) St. Mary-Belly River (USFWS 2002a; 2004a; 2004b). Each of these interim recovery units is necessary to maintain the bull trout's distribution, as well as its genetic and phenotypic diversity, all of which are important to ensure the species' resilience to changing environmental conditions.

A summary of the current status and conservation needs of the bull trout within these interim recovery units is provided below and a comprehensive discussion is found in the Service's draft recovery plans for the bull trout (USFWS 2002a; 2004a; 2004b).

The conservation needs of bull trout are often generally expressed as the four "Cs": cold, clean, complex, and connected habitat. Cold stream temperatures, clean water quality that is relatively free of sediment and contaminants, complex channel characteristics (including abundant large wood and undercut banks), and large patches of such habitat that are well connected by unobstructed migratory pathways are all needed to promote conservation of bull trout at multiple scales ranging from the coterminous to local populations (a local population is a group of bull trout that spawn within a particular stream or portion of a stream system). The recovery planning process for bull trout (USFWS 2002a; 2004a; 2004b) has also identified the following conservation needs: 1) maintenance and restoration of multiple, interconnected populations in diverse habitats across the range of each interim recovery unit, 2) preservation of the diversity of life-history strategies, 3) maintenance of genetic and phenotypic diversity across the range of each interim recovery unit, and 4) establishment of a positive population trend. Recently, it has also been recognized that bull trout populations need to be protected from catastrophic fires across the range of each interim recovery unit (Rieman et al. 2003).

Central to the survival and recovery of bull trout is the maintenance of viable core areas (USFWS 2002a; 2004a; 2004b). A core area is defined as a geographic area occupied by one or more local bull trout populations that overlap in their use of rearing, foraging, migratory, and overwintering habitat. Each of the interim recovery units listed above consists of one or more core areas. There are 121 core areas recognized across the coterminous range of the bull trout (USFWS 2002a; 2004a; 2004b).

Jarbidge River Interim Recovery Unit

This interim recovery unit currently contains a single core area with six local populations. Less than 500 resident and migratory adult bull trout, representing about 50 to 125 spawning adults, are estimated to occur in the core area. The current condition of the bull trout in this interim recovery unit is attributed to the effects of livestock grazing, roads, incidental mortalities of released bull trout from recreational angling, historic angler harvest, timber harvest, and the introduction of non-native fishes (USFWS 2004b). The draft bull trout recovery plan (USFWS 2004b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout within the core area, 2) maintain stable or increasing trends in abundance of both resident and migratory bull trout in the core area, 3) restore and maintain suitable habitat conditions for all life history stages and forms, and 4) conserve genetic diversity and increase natural opportunities for genetic exchange between resident and migratory forms of the bull trout. An estimated 270 to 1,000 spawning bull trout per year are needed to provide for the persistence and viability of the core area and to support both resident and migratory adult bull trout (USFWS 2004b).

Klamath River Interim Recovery Unit

This interim recovery unit currently contains three core areas and seven local populations. The current abundance, distribution, and range of the bull trout in the Klamath River Basin are greatly reduced from historical levels due to habitat loss and degradation caused by reduced water quality, timber harvest, livestock grazing, water diversions, roads, and the introduction of non-native fishes ((USFWS 2002b). Bull trout populations in this interim recovery unit face a high risk of extirpation (USFWS 2002b). The draft Klamath River bull trout recovery plan (USFWS 2002b) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and strategies, 4) conserve genetic diversity and provide the opportunity for genetic exchange among appropriate core area populations. Eight to 15 new local populations and an increase in population size from about 2,400 adults currently to 8,250 adults are needed to provide for the persistence and viability of the three core areas (USFWS 2002b).

Columbia River Interim Recovery Unit

The Columbia River interim recovery unit includes bull trout residing in portions of Oregon, Washington, Idaho, and Montana. Bull trout are estimated to have occupied about 60 percent of the Columbia River Basin, and presently occur in 45 percent of the estimated historical range (Quigley and Arbelbide 1997). This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in central Idaho and northwestern Montana. The Columbia River interim recovery unit has declined in overall range and numbers of fish (63 FR 31647). Although some strongholds still exist with migratory fish present, bull trout generally occur as isolated local populations in headwater lakes or tributaries where the migratory life history form has been lost. Though still widespread, there have been numerous local extirpations reported throughout the Columbia River basin. In Idaho, for example, bull trout have been extirpated from 119 reaches in 28 streams (Idaho Department of Fish and Game *in litt.* 1995). The draft Columbia River bull trout recovery plan (USFWS 2002d) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of the bull trout within core areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all bull trout life history stages and strategies, and 4) conserve genetic diversity and provide opportunities for genetic exchange.

This interim recovery unit currently contains 97 core areas and 527 local populations. About 65 percent of these core areas and local populations occur in Idaho and northwestern Montana. The condition of the bull trout within these core areas varies from poor to good. All core areas have been subject to the combined effects of habitat degradation and fragmentation caused by the following activities: dewatering; road construction and maintenance; mining; grazing; the blockage of migratory corridors by dams or other diversion structures; poor water quality; incidental angler harvest; entrainment into diversion channels; and introduced non-native species. The Service completed a core area conservation assessment for the 5-year status review and determined that, of the 97 core areas in this interim recovery unit, 38 are at high risk of extirpation, 35 are at risk, 20 are at potential risk, 2 are at low risk, and 2 are at unknown risk (USFWS 2005).

Coastal-Puget Sound Interim Recovery Unit

Bull trout in the Coastal-Puget Sound interim recovery unit exhibit anadromous, adfluvial, fluvial, and resident life history patterns. The anadromous life history form is unique to this interim recovery unit. This interim recovery unit currently contains 14 core areas and 67 local populations (USFWS 2004a). Bull trout are distributed throughout most of the large rivers and associated tributary systems within this interim recovery unit. Bull trout continue to be present in nearly all major watersheds where they likely occurred historically, although local extirpations have occurred throughout this interim recovery unit. Many remaining populations are isolated or fragmented and abundance has declined, especially in the southeastern portion of the interim recovery unit. The current condition of the bull trout in this interim recovery unit is attributed to the adverse effects of dams, forest management practices (e.g., timber harvest and associated road building activities), agricultural practices (e.g., diking, water control structures, draining of wetlands, channelization, and the removal of riparian vegetation), livestock grazing, roads, mining, urbanization, poaching, incidental mortality from other targeted fisheries, and the introduction of non-native species. The draft Coastal-Puget Sound bull trout recovery plan (USFWS 2004a) identifies the following conservation needs for this interim recovery unit: 1) maintain or expand the current distribution of bull trout within existing core areas, 2) increase bull trout abundance to about 16,500 adults across all core areas, and 3) maintain or increase connectivity between local populations within each core area.

St. Mary-Belly River Interim Recovery Unit

This interim recovery unit currently contains six core areas and nine local populations (USFWS 2002c). Currently, bull trout are widely distributed in the St. Mary-Belly River drainage and occur in nearly all of the waters that it inhabited historically. Bull trout are found only in a 1.2-mile reach of the North Fork Belly River within the United States. Redd count surveys of the North Fork Belly River documented an increase from 27 redds in 1995 to 119 redds in 1999. This increase was attributed primarily to protection from angler harvest (USFWS 2002c). The current condition of the bull trout in this interim recovery unit is primarily attributed to the effects of dams, water diversions, roads, mining, and the introduction of non-native fishes (USFWS 2002c). The draft St. Mary-Belly bull trout recovery plan (USFWS 2002c) identifies the following conservation needs for this interim recovery unit: 1) maintain the current distribution of the bull trout and restore distribution in previously occupied areas, 2) maintain stable or increasing trends in bull trout abundance, 3) restore and maintain suitable habitat conditions for all life history stages and forms, 4) conserve genetic diversity and provide the opportunity for genetic exchange, and 5) establish good working relations with Canadian interests because local bull trout populations in this interim recovery unit are comprised mostly of migratory fish, whose habitat is mostly in Canada.

## Life History

Bull trout exhibit both resident and migratory life history strategies. Both resident and migratory forms may be found together, and either form may produce offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993). Resident bull trout complete their entire life cycle in the tributary (or nearby) streams in which they spawn and rear. The resident form tends to be smaller than the migratory form at maturity and also produces fewer eggs (Fraley and Shepard 1989; Goetz 1989). Migratory bull trout spawn in tributary streams where juvenile fish rear 1 to 4 years before migrating to either a lake (adfluvial form), river (fluvial form) (Fraley and Shepard 1989; Goetz 1989), or saltwater (anadromous form) to rear as subadults and to live as adults (Cavender 1978; McPhail and Baxter 1996; WDFW et al. 1997). Bull trout normally reach sexual maturity in 4 to 7 years and may live longer than 12 years. They are iteroparous (they spawn more than once in a lifetime). Repeat- and alternate-year spawning has been reported, although repeat-spawning frequency and post-spawning mortality are not well documented (Leathe and Graham 1982; Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1996).

The iteroparous reproductive strategy of bull trout has important repercussions for the management of this species. Bull trout require passage both upstream and downstream, not only for repeat spawning but also for foraging. Most fish ladders, however, were designed specifically for anadromous semelparous salmonids (fishes that spawn once and then die, and require only one-way passage upstream). Therefore, even dams or other barriers with fish passage facilities may be a factor in isolating bull trout populations if they do not provide a downstream passage route. Additionally, in some core areas, bull trout that migrate to marine waters must pass both upstream and downstream through areas with net fisheries at river mouths. This can increase the likelihood of mortality to bull trout during these spawning and foraging migrations.

Growth varies depending upon life-history strategy. Resident adults range from 6 to 12 inches total length, and migratory adults commonly reach 24 inches or more (Pratt 1985; Goetz 1989). The largest verified bull trout is a 32-pound specimen caught in Lake Pend Oreille, Idaho, in 1949 (Simpson and Wallace 1982).

## Habitat Characteristics

Bull trout have more specific habitat requirements than most other salmonids (Rieman and McIntyre 1993). Habitat components that influence bull trout distribution and abundance include water temperature, cover, channel form and stability, valley form, spawning and rearing substrate, and migratory corridors (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Howell and Buchanan 1992; Pratt 1992; Rieman and McIntyre 1993; Rieman and McIntyre 1995; Rich 1996; Watson and Hillman 1997). Watson and Hillman (1997) concluded that watersheds must have specific physical characteristics to provide the habitat requirements necessary for bull trout to successfully spawn and rear and that these specific characteristics are not necessarily present throughout these watersheds. Because bull trout exhibit a patchy distribution, even in pristine habitats (Rieman and McIntyre 1993), bull trout should not be expected to simultaneously occupy all available habitats (Rieman et al. 1997).

Migratory corridors link seasonal habitats for all bull trout life histories. The ability to migrate is important to the persistence of bull trout (Rieman and McIntyre 1993; Rieman et al. 1997; Mike Gilpin *in litt.* 1997). Migrations facilitate gene flow among local populations when individuals from different local populations interbreed or stray to nonnatal streams. Local populations that are extirpated by catastrophic events may also become reestablished by bull trout migrants. However, it is important to note that the genetic structuring of bull trout indicates there is limited gene flow among bull trout populations, which may encourage local adaptation within individual populations, and that reestablishment of extirpated populations may take a long time (Rieman and McIntyre 1993; Spruell et al. 1999). Migration also allows bull trout to access more abundant or larger prey, which facilitates growth and reproduction. Additional benefits of migration and its relationship to foraging are discussed below under "Diet."

Cold water temperatures play an important role in determining bull trout habitat quality, as these fish are primarily found in colder streams (below 15 °C or 59 °F), and spawning habitats are generally characterized by temperatures that drop below 9 °C (48 °F) in the fall (Fraley and Shepard 1989; Pratt 1992; Rieman and McIntyre 1993).

Thermal requirements for bull trout appear to differ at different life stages. Spawning areas are often associated with cold-water springs, groundwater infiltration, and the coldest streams in a given watershed (Pratt 1992; Rieman and McIntyre 1993; Baxter et al. 1997; Rieman et al. 1997). Optimum incubation temperatures for bull trout eggs range from 2 °C to 6 °C (35 °F to 39 °F) whereas optimum water temperatures for rearing range from about 6 °C to 10 °C (46 °F to 50 °F) (McPhail and Murray 1979; Goetz 1989; Buchanan and Gregory 1997). In Granite Creek, Idaho, Bonneau and Scarnecchia (1996) observed that juvenile bull trout selected the coldest water available in a plunge pool, 8 °C to 9 °C (46 °F to 48 °F), within a temperature gradient of 8 °C to 15 °C (4 °F to 60 °F). In a landscape study relating bull trout distribution to maximum water temperatures, Dunham et al. (2003) found that the probability of juvenile bull trout occurrence does not become high (i.e., greater than 0.75) until maximum temperatures decline to 11 °C to 12 °C (52 °F to 54 °F).

Although bull trout are found primarily in cold streams, occasionally these fish are found in larger, warmer river systems throughout the Columbia River basin (Fraley and Shepard 1989; Rieman and McIntyre 1993; Rieman and McIntyre 1995; Rieman et al. 1997; Buchanan and Gregory 1997). Availability and proximity of cold water patches and food productivity can influence bull trout ability to survive in warmer rivers (Myrick et al. 2002). For example, in a study in the Little Lost River of Idaho where bull trout were found at temperatures ranging from 8 °C to 20 °C (46 °F to 68 °F), most sites that had high densities of bull trout were in areas where primary productivity in streams had increased following a fire (Bart L. Gamett, Salmon-Challis National Forest, pers. comm. June 20, 2002).

All life history stages of bull trout are associated with complex forms of cover, including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Goetz 1989; Hoelscher and Bjornn 1989; Sedell and Everest 1991; Pratt 1992; Thomas 1992; Rich 1996; Sexauer and James 1997; Watson and Hillman 1997). Maintaining bull trout habitat requires stability of stream channels and maintenance of natural flow patterns (Rieman and McIntyre

1993). Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover (Sexauer and James 1997). These areas are sensitive to activities that directly or indirectly affect stream channel stability and alter natural flow patterns. For example, altered stream flow in the fall may disrupt bull trout during the spawning period, and channel instability may decrease survival of eggs and young juveniles in the gravel from winter through spring (Fraley and Shepard 1989; Pratt 1992; Pratt and Huston 1993). Pratt (1992) indicated that increases in fine sediment reduce egg survival and emergence.

Bull trout typically spawn from August through November during periods of increasing flows and decreasing water temperatures. Preferred spawning habitat consists of low-gradient stream reaches with loose, clean gravel (Fraley and Shepard 1989). Redds are often constructed in stream reaches fed by springs or near other sources of cold groundwater (Goetz 1989; Pratt 1992; Rieman and McIntyre 1996). Depending on water temperature, incubation is normally 100 to 145 days (Pratt 1992). After hatching, fry remain in the substrate, and time from egg deposition to emergence may surpass 200 days. Fry normally emerge from early April through May, depending on water temperatures and increasing stream flows (Pratt 1992; Ratliff and Howell 1992).

Early life stages of fish, specifically the developing embryo, require the highest inter-gravel dissolved oxygen (IGDO) levels, and are the most sensitive life stage to reduced oxygen levels. The oxygen demand of embryos depends on temperature and on stage of development, with the greatest IGDO required just prior to hatching.

A literature review conducted by the Washington Department of Ecology (WDOE 2002) indicates that adverse effects of lower oxygen concentrations on embryo survival are magnified as temperatures increase above optimal (for incubation). In a laboratory study conducted in Canada, researchers found that low oxygen levels retarded embryonic development in bull trout (Giles and Van der Zweep 1996 in Stewart et al. 2007). Normal oxygen levels seen in rivers used by bull trout during spawning ranged from 8 to 12 mg/L (in the gravel), with corresponding instream levels of 10 to 11.5 mg/L (Stewart et al. 2007). In addition, IGDO concentrations, water velocities in the water column, and especially the intergravel flow rate, are interrelated variables that affect the survival of incubating embryos (ODEQ 1995). Due to a long incubation period of 220+ days, bull trout are particularly sensitive to adequate IGDO levels. An IGDO level below 8 mg/L is likely to result in mortality of eggs, embryos, and fry.

Migratory forms of bull trout may develop when habitat conditions allow movement between spawning and rearing streams and larger rivers, lakes or nearshore marine habitat where foraging opportunities may be enhanced (Frissell 1993; Goetz et al. 2004; Brenkman and Corbett 2005). For example, multiple life history forms (e.g., resident and fluvial) and multiple migration patterns have been noted in the Grande Ronde River (Baxter 2002). Parts of this river system have retained habitat conditions that allow free movement between spawning and rearing areas and the mainstem Snake River. Such multiple life history strategies help to maintain the stability and persistence of bull trout populations to environmental changes. Benefits to migratory bull trout include greater growth in the more productive waters of larger streams, lakes, and marine waters; greater fecundity resulting in increased reproductive potential; and dispersing the population across space and time so that spawning streams may be recolonized should local populations suffer a catastrophic loss (Rieman and McIntyre 1993; MBTSG 1998; Frissell 1999). In the absence of the migratory bull trout life form, isolated populations cannot be replenished when disturbances make local habitats temporarily unsuitable. Therefore, the range of the species is diminished, and the potential for a greater reproductive contribution from larger size fish with higher fecundity is lost (Rieman and McIntyre 1993).

**Diet**

Bull trout are opportunistic feeders, with food habits primarily a function of size and life-history strategy. A single optimal foraging strategy is not necessarily a consistent feature in the life of a fish, because this strategy can change as the fish progresses from one life stage to another (i.e., juvenile to subadult). Fish growth depends on the quantity and quality of food that is eaten (Gerking 1994), and as fish grow, their foraging strategy changes as their food changes, in quantity, size, or other characteristics. Resident and juvenile migratory bull trout prey on terrestrial and aquatic insects, macrozooplankton, and small fish (Boag 1987; Goetz 1989; Donald and Alger 1993). Subadult and adult migratory bull trout feed on various fish species (Leathe and Graham 1982; Fraley and Shepard 1989; Donald and Alger 1993; Brown 1994). Bull trout of all sizes other than fry have been found to eat fish half their length (Beauchamp and VanTassell 2001). In nearshore marine areas of western Washington, bull trout feed on Pacific herring (*Clupea pallasi*), Pacific sand lance (*Ammodytes hexapterus*), and surf smelt (*Hypomesus pretiosus*) (WDFW et al. 1997; Goetz et al. 2004).

Bull trout migration and life history strategies are closely related to their feeding and foraging strategies. Migration allows bull trout to access optimal foraging areas and exploit a wider variety of prey resources. Optimal foraging theory can be used to describe strategies fish use to choose between alternative sources of food by weighing the benefits and costs of capturing one source of food over another. For example, prey often occur in concentrated patches of abundance ("patch model" ; Gerking 1994). As the predator feeds in one patch, the prey population is reduced, and it becomes more profitable for the predator to seek a new patch rather than continue feeding on the original one. This can be explained in terms of balancing energy acquired versus energy expended. For example, in the Skagit River system, anadromous bull trout make migrations as long as 121 miles between marine foraging areas in Puget Sound and headwater spawning grounds, foraging on salmon eggs and juvenile salmon along their migration route (WDFW et al. 1997). Anadromous bull trout also use marine waters as migration corridors to reach seasonal habitats in non-natal watersheds to forage and possibly overwinter (Goetz et al. 2004; Brenkman and Corbett 2005).

Changes in Status of the Coastal-Puget Sound Interim Recovery Unit

Although the status of bull trout in Coastal-Puget Sound interim recovery unit has been improved by certain actions, it continues to be degraded by other actions, and it is likely that the overall status of the bull trout in this population segment has not improved since its listing on November 1, 1999. Improvement has occurred largely through changes in fishing regulations and habitat-restoration projects. Fishing regulations enacted in 1994 either eliminated harvest of bull trout or restricted the amount of harvest allowed, and this likely has had a positive influence on the abundance of bull trout. Improvement in habitat has occurred following restoration projects intended to benefit either bull trout or salmon, although monitoring the effectiveness of these projects seldom occurs. On the other hand, the status of this population segment has been adversely affected by a number of Federal and non-Federal actions, some of which were addressed under section 7 of the Act. Most of these actions degraded the environmental baseline; all of those addressed through formal consultation under section 7 of the Act permitted the incidental take of bull trout.

Section 10(a)(1)(B) permits have been issued for Habitat Conservation Plans (HCP) completed in the Coastal-Puget Sound population segment. These include: 1) the City of Seattle's Cedar River Watershed HCP, 2) Simpson Timber HCP, 3) Tacoma Public Utilities Green River HCP, 4) Plum Creek Cascades HCP, 5) Washington State Department of Natural Resources HCP, 6) West Fork Timber HCP (Nisqually River), and 7) Forest Practices HCP. These HCPs provide landscape-scale conservation for fish, including bull trout. Many of the covered activities associated with these HCPs will contribute to conserving bull trout over the long-term; however, some covered activities will result in short-term degradation of the baseline. All HCPs permit the incidental take of bull trout.

<u>Changes in Status of the Columbia River Interim Recovery Unit</u>

The overall status of the Columbia River interim recovery unit has not changed appreciably since its listing on June 10, 1998. Populations of bull trout and their habitat in this area have been affected by a number of actions addressed under section 7 of the Act. Most of these actions resulted in degradation of the environmental baseline of bull trout habitat, and all permitted or analyzed the potential for incidental take of bull trout. The Plum Creek Cascades HCP, Plum Creek Native Fish HCP, and Forest Practices HCP addressed portions of the Columbia River population segment of bull trout.

<u>Changes in Status of the Klamath River Interim Recovery Unit</u>

Improvements in the Threemile, Sun, and Long Creek local populations have occurred through efforts to remove or reduce competition and hybridization with non-native salmonids, changes in fishing regulations, and habitat-restoration projects. Population status in the remaining local populations (Boulder-Dixon, Deming, Brownsworth, and Leonard Creeks) remains relatively unchanged. Grazing within bull trout watersheds throughout the recovery unit has been curtailed. Efforts at removal of non-native species of salmonids appear to have stabilized the Threemile and positively influenced the Sun Creek local populations. The results of similar efforts in Long Creek are inconclusive. Mark and recapture studies of bull trout in Long Creek indicate a larger migratory component than previously expected.

Although the status of specific local populations has been slightly improved by recovery actions, the overall status of Klamath River bull trout continues to be depressed. Factors considered threats to bull trout in the Klamath Basin at the time of listing – habitat loss and degradation caused by reduced water quality, past and present land use management practices, water diversions, roads, and non-native fishes – continue to be threats today.

Changes in Status of the Saint Mary-Belly River Interim Recovery Unit

The overall status of bull trout in the Saint Mary-Belly River interim recovery unit has not changed appreciably since its listing on November 1, 1999. Extensive research efforts have been conducted since listing, to better quantify populations of bull trout and their movement patterns. Limited efforts in the way of active recovery actions have occurred. Habitat occurs mostly on Federal and Tribal lands (Glacier National Park and the Blackfeet Nation). Known problems due to instream flow depletion, entrainment, and fish passage barriers resulting from operations of the U.S. Bureau of Reclamation's Milk River Irrigation Project (which transfers Saint Mary-Belly River water to the Missouri River Basin) and similar projects downstream in Canada constitute the primary threats to bull trout and to date they have not been adequately addressed under section 7 of the Act. Plans to upgrade the aging irrigation delivery system are being pursued, which has potential to mitigate some of these concerns but also the potential to intensify dewatering. A major fire in August 2006 severely burned the forested habitat in Red Eagle and Divide Creeks, potentially affecting three of nine local populations and degrading the baseline.

## STATUS OF CRITICAL HABITAT (Bull Trout; Coterminous Range)

The status of murrelets within their listed range is provided in Appendix B.

## ENVIRONMENTAL BASELINE (Bull Trout and Designated Critical Habitat)

Regulations implementing the Act (50 CFR section 402.02) define the environmental baseline as the past and present impacts of all Federal, State, or private actions and other human activities in the action area. Also included in the environmental baseline are the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of State and private actions which are contemporaneous with the consultation in progress.

Description of the Action Area

The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR section 402.02). As such, the action area includes the extent of the physical, biotic, and chemical effects of the action on the environment.

The terrestrial boundaries of the action area were defined based on the extent of temporary sound and visual disturbance that will result during construction. Temporary increases in sound associated with impact pile driving and proofing are expected to have the farthest reaching effects in the terrestrial environment. Increased sound levels will exceed ambient in-air sound levels to a distance of approximately 2 miles in all directions from the South Park Bridge over the lower Duwamish River (Figure 4).

The aquatic boundaries of the action area were defined with consideration for where and how far work activities may temporarily increase underwater SPLs as a result of piling installation operations, where temporary increases in turbidity and sedimentation may result from construction, and where and how far re-suspended sediments contaminated with metals, polycyclic aromatic hydrocarbons (PAHs), and/or PCBs may travel before resettling. Downstream transport of fine-grained sediments (silts and clays) is expected to have the farthest reaching effects in the aquatic environment. The best available science would lead us to conclude that a portion of the re-suspended sediments, and the sediment-bound metal, PAH, and PCB concentrations they carry, may travel the entire length of the lower Duwamish River and into Elliot Bay (a distance of approximately 5 miles downstream) before falling out of suspension (Figure 4).

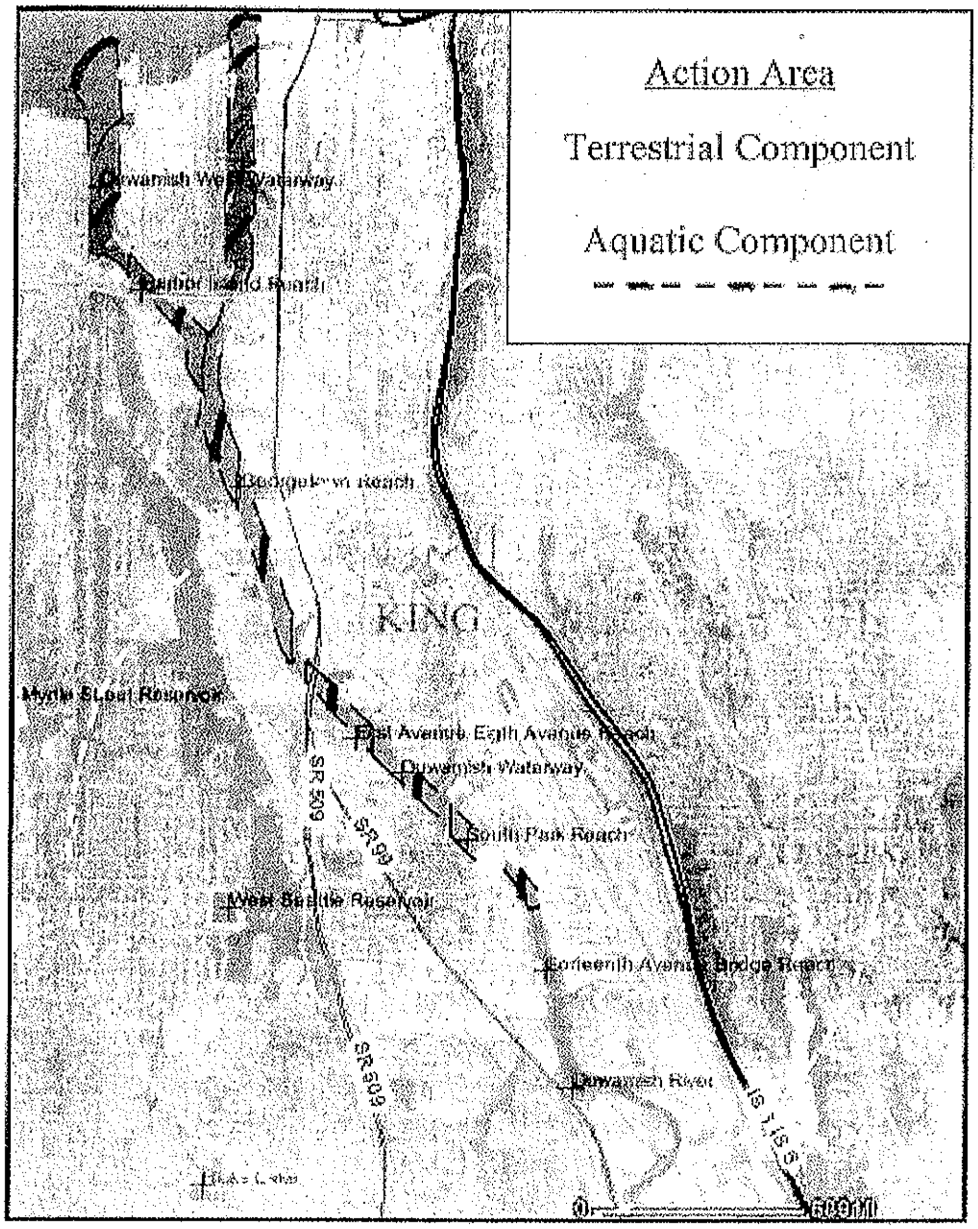



Figure 4. Aerial photo depicting extent of the action area.

The proposed project will not increase traffic capacity within the project limits. No new development is contingent or dependent upon the project's completion and the FWS does not expect any discernible changes in the rate or pattern of land use conversion will result, in whole or in part, from construction of the project.

The project will dispose of any characteristically hazardous or toxic waste at an approved upland disposal site, or at an approved in-water dredged material disposal site operating under the DMMP (KCDOT 2009, WDNR 2009). Sites operating under the DMMP were addressed with an earlier consultation (1-3-05-I-0298/IC-0299). Those sites, and any effects associated with their management, are not addressed in this Opinion.

Environmental Baseline in the Action Area

Land use throughout the action area is almost exclusively industrial, commercial/light-industrial, and dense urban residential. Lands within the action area are zoned "General Industrial", "Industrial Commercial", "Industrial Buffer", "Commercial", "Neighborhood Commercial", "Residential, Multifamily", "Residential, Single-family", etc. (City of Seattle 2009). Throughout the action area the lower Duwamish River and its floodplain are very heavily developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other activities (LDWG 2009a). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact (Kerwin and Nelson 2000).

The lower Duwamish River plays an important role as migratory habitat for all salmon and steelhead of the Green-Duwamish watershed. These populations include: Green River Chinook salmon (*Oncorhynchus tshawytscha*; status rated as "healthy"), Duwamish/Green and Crisp Creek fall chum salmon (*O. keta*; status "unknown"), Green River/Soos Creek coho salmon (*O. kisutch*; status "healthy"), and Green River summer and winter steelhead (*O. mykiss*; status "depressed" and "healthy" respectively) (WDFW 2002). The waters within the action area are also presumed to support sea run coastal cutthroat trout (*O. clarki*) and anadromous bull trout. The lower Duwamish River and nearshore marine waters of Elliot Bay are designated as critical habitat for bull trout (Unit 28 – Puget Sound) [70 FR 56212 (September 26, 2005)]. These waters are also identified by the draft Bull Trout Recovery Plan (USFWS 2004) as important foraging, migration, and overwintering (FMO) habitat.

Factors that limit salmonid productivity in the action area include: floodplain modification and loss of hydrologic connectivity with estuarine wetlands, fragmented and heavily degraded riparian conditions, reduced instream habitat complexity (including channelization, bank hardening, reduced large woody debris inputs, degraded substrate conditions, and loss of pool, refuge, and off-channel habitat), impaired surface water and sediment quality, loss or degradation of nearshore habitats and habitat forming processes, and fish passage barriers (Kerwin and Nelson 2000).

The current baseline instream habitat and watershed conditions were assessed with the *Matrix of Diagnostics / Pathways and Indicators* (USFWS 1998). The matrix provides a framework for considering the effects of individual or grouped actions on habitat elements and processes important to the complete life cycle of bull trout. The BA submitted by the FHWA applied the matrix in describing baseline environmental conditions at the scale of the action area (KCDOT 2008). Those descriptions are incorporated here by reference, and what follows is a brief summary: the waters within the action area are *functioning at unacceptable levels of risk* for 18 of 22 indicators, including temperature, chemical contamination / nutrients, substrate, pool frequency / quality, off-channel habitat, refugia, floodplain connectivity, and riparian reserves; and, the waters within the action area are not *functioning adequately* for any indicator, except width / depth ratio.

The FWS has used additional information to characterize the chemical contamination indicator. The sub-section that follows presents information from the BA and other sources as cited.

*Chemical Contamination Indicator*

The U.S. Environmental Protection Agency (EPA) has placed a large portion of the lower Duwamish River, or Duwamish Waterway, onto the National Priorities ("Superfund") List (WDOE 2009a). Sources of toxic surface water and sediment contamination, and the feasibility of various source control and corrective actions, have been the focus of intensive study since the mid-1970s (LDWG 2009a). Related corrective actions began as early as the 1950s and 60s with curtailment of toxic industrial discharges and improved or replaced sewer and water treatment infrastructure, and have continued to the present in the form of hazardous waste disposal programs, preservation and/or restoration of intertidal habitats, control and/or retrofit of combined sewer overflows and further improvements to sewer and water treatment infrastructure, and clean-up (removal and disposal) of soil, water, and sediment contamination at a number of locations along the lowermost 6 miles (approximate) (LDWG 2009a,b). The members of the Lower Duwamish Waterway Group (LDWG), including the Port of Seattle, City of Seattle, King County, and the Boeing Company, have entered into a voluntary agreement with the EPA and WDOE to improve and better coordinate investigative and feasibility studies, and to prioritize, strategically plan, and complete corrective actions and clean-ups.

The proposed action, replacement of the South Park Bridge, is located within one of seven "Early Action Areas" (EAAs) identified for the Lower Duwamish Waterway Superfund Site (Boeing Plant 2 / Jorgensen Forge), and is also in close (downstream) proximity to a second EAA (Terminal 117) (WDOE 2009a). The Boeing Plant 2 / Jorgensen Forge EAA is bisected by 16$^{th}$ Avenue South and the South Park Bridge (Figure 5). Clean-up and other remedial actions are at various stages of completion at additional EAAs, both upstream (Norfolk CSO) and downstream (Duwamish / Diagonal, Slip 4) of the South Park reach (LDWG 2009b).

Individual Aroclor PCBs, Total PCBs, carcinogenic PAHs, phthalates, and metals have been identified as contaminants of concern for the Boeing Plant 2 / Jorgensen Forge EAA (WDOE 2009b). Boeing Plant 2 is an approximately 107-acre site in operation since 1936. Boeing is currently investigating and cleaning-up contaminated soil and groundwater from the site under a Resource Conservation and Recovery Act order (EPA 2009a). Complete and final clean-up, including removal and disposal of hazardous waste from contaminated river sediments, is not foreseen for several more years. To date, interim control measures at Boeing Plant 2 have included removal of PCB-contaminated soils, groundwater treatment, and closure of storm drains to prevent discharges to the Duwamish River (EPA 2009a). Jorgensen Forge is an approximately 22-acre site in operation as a steel and alloy forging plant and distribution center since 1942 (WDOE 2009c). Investigations at the Jorgensen Forge site have detected soil concentrations exceeding applicable clean-up levels for PCBs, total petroleum hydrocarbons, and various metals. The Jorgensen Forge Corporation is currently conducting investigations under a Resource Conservation and Recovery Act

Source: WDOE 2009b
Figure 5. Aerial view depicting the Boeing Plant 2 / Jorgensen Forge EAA.

order to determine if the site is an ongoing source of contamination to sediments in the Duwamish River (WDOE 2009c).

The amount of information describing conditions in the Lower Duwamish Waterway Superfund Site, or even just the Boeing Plant 2 / Jorgensen Forge EAA, is voluminous (WDOE 2009a; EPA 2009b) and cannot be concisely summarized here. However, to characterize sediment quality in the vicinity of the planned bridge replacement (i.e., along the South Park reach), the BA and Addendum (KCDOT 2008, 2009) relied upon sampling data collected from approximately 226 locations within 500 meters upstream and downstream of the existing South Park Bridge (Herrera 2007). These data were collected from both surface and sub-surface samples.

KCDOT has provided summary statistics (i.e., minimum, median, 95[th] percentile, and maximum concentrations) to describe sediment quality along the South Park reach with respect to approximately 196 chemical parameters (Herrera 2007). Table 3 reports these summary statistics for the contaminants of greatest concern at the Boeing Plant 2 / Jorgensen Forge EAA, including Aroclor PCBs, Total PCBs, carcinogenic PAHs, and metals.

Table 3. Summary statistics for select sediment chemical parameters.

| Parameter Name | Units | Count | Non Area-weighted Statistics | | | |
|---|---|---|---|---|---|---|
| | | | Minimum | Median | 95th Percentile | Maximum |
| **Metals** | | | | | | |
| Copper | mg/kg | 124 | 14.00 | 46.00 | 350.00 | 12,000.00 |
| Lead | mg/kg | 123 | 8.00 | 44.00 | 1,900.00 | 23,000.00 |
| Zinc | mg/kg | 122 | 48.70 | 141.00 | 1,200.00 | 9,700.00 |
| **PAHs** | | | | | | |
| Acenaphthene | ug/kg | 105 | 19.00 | 85.00 | 220.00 | 760.00 |
| Anthracene | ug/kg | 93 | 19.00 | 81.00 | 290.00 | 540.00 |
| Benzo(a)anthracene | ug/kg | 105 | 33.30 | 140.00 | 940.00 | 2,200.00 |
| Benzo(a)pyrene | ug/kg | 105 | 36.70 | 145.00 | 920.00 | 1,600.00 |
| Benzo(b)fluoranthene | ug/kg | 105 | 40.00 | 180.00 | 1,700.00 | 2,800.00 |
| Benzo(g,h,i)perylene | ug/kg | 105 | 33.30 | 110.00 | 440.00 | 700.00 |
| Benzo(k)fluoranthene | ug/kg | 105 | 36.67 | 150.00 | 1,200.00 | 2,000.00 |
| Chrysene | ug/kg | 105 | 43.00 | 220.00 | 1,600.00 | 2,800.00 |
| Dibenzo(a,h)anthracene | ug/kg | 104 | 19.00 | 83.50 | 240.00 | 330.00 |
| Fluoranthene | ug/kg | 105 | 75.00 | 350.00 | 2,300.00 | 5,300.00 |
| Fluorene | ug/kg | 104 | 19.00 | 84.00 | 170.00 | 500.00 |
| Indeno(1,2,3-c,d)pyrene | ug/kg | 105 | 33.30 | 110.00 | 520.00 | 830.00 |
| Phenanthrene | ug/kg | 105 | 44.00 | 150.00 | 1,200.00 | 2,100.00 |
| Pyrene | ug/kg | 105 | 73.30 | 330.00 | 2,200.00 | 5,200.00 |
| **PCBs** | | | | | | |
| Aroclor-1248 | ug/kg | 188 | 6.70 | 61.00 | 1,015.00 | 12,550.00 |
| Aroclor-1254 | ug/kg | 188 | 9.70 | 240.00 | 3,366.70 | 67,150.00 |
| Aroclor-1260 | ug/kg | 188 | 9.40 | 445.00 | 8,000.00 | 458,000.00 |
| Total PCBs | ug/kg | 226 | 14.00 | 662.50 | 10,200.00 | 458,000.00 |

Source: Herrera 2007

Washington State's marine sediment quality standards (SQSs) are established for the protection of marine biological resources and, "correspond to a sediment quality that will result in ... no acute or chronic adverse effects" (WAC 173-204-320). The State's marine clean-up screening levels (CSLs) are associated with "minor adverse effects", "levels above which [locations] are defined as clean-up sites" (WAC 173-204-520). It is important to note that, to date, the WDOE and EPA have not consulted with the FWS (or the National Marine Fisheries Service) regarding these standards; the FWS has not determined whether adverse effects to the Act-listed species or critical habitat might occur at the concentrations prescribed by these standards.

Freshwater sediment quality guidelines (SQGs) are "numerical limits recommended to support and maintain aquatic life", and generally reflect the sensitivities of sediment-dwelling organisms (Marsalek 2002, p. 6; MacDonald *et al.* 2000, p. 20). The EPA has published guidance for the derivation of sediment benchmarks (EPA 2009c), and the WDOE implements several programs (e.g., Aquatic Lands Clean-Up, Water Quality, Environmental Assessment, etc.) engaged in the development and refinement of SQGs (WDOE 2009d). MacDonald *et al.* (2000) provide a good summary of published freshwater SQGs. SQGs derived using an effects level approach are in fairly wide use. Threshold Effect Levels (TELs) identify sediment concentrations below which no adverse effects to freshwater biota are expected. Probable Effect Levels (PELs) identify sediment concentrations above which adverse effects to freshwater biota are frequently expected to occur. To date, the State of Washington has not adopted freshwater SQGs (King Co. 2009); interim freshwater SQGs currently in use in King County and the State of Washington were derived using an effects level approach (King Co. 2009; Smith *et al.* 1996).

Washington State's Model Toxics Control Act (MTCA) clean-up levels specify "the concentration[s] of a hazardous substance in soil, water, air or sediment that [are] ... protective of human health and the environment" (WAC 173-340-700). When applied in conjunction with a point(s) of compliance, MTCA Method A levels (MTCA Level A) define the area or volume of media that must be addressed as part of a routine clean-up action. As with the State's marine SQSs and CSLs, the WDOE and EPA have not consulted with the FWS regarding these standards; the FWS has not determined whether adverse effects to the Act-listed species or critical habitat might occur at the concentrations prescribed by these standards.

Table 4 presents median and 95$^{th}$ percentile sediment concentrations along the South Park reach (Herrera 2007) and allows for comparisons with contaminant-specific marine standards (SQSs and CSLs), interim freshwater sediment guidelines (SQGs; TELs and PELs), and MTCA Method A clean-up levels. Median metal concentrations exceed TELs, and the 95$^{th}$ percentile concentrations approach or exceed SQSs, CSLs, PELs, and MTCA Level A. Median sediment concentrations for six PAHs exceed TELs, and the 95$^{th}$ percentile concentrations for five PAHs exceed PELs. Mean and 95$^{th}$ percentile sediment concentrations of benzo(a)pyrene, a PAH for which a MTCA Level A is available, both greatly exceed the standard. Median Total PCB concentration greatly exceeds the TEL and PEL, and the 95$^{th}$ percentile sediment concentration greatly exceeds MTCA Level A.

Available data suggest that levels of sediment contamination vary substantially throughout the South Park reach. Figure 6 depicts Total PCB concentrations at seven sample depths along the reach and in proximity to the existing South Park Bridge. Other contaminants of concern (carcinogenic PAHs, metals, etc.) have similarly variable, but unique spatial distributions throughout the reach (LDWG 2007, pp. 146-7, 197, Maps 4-20d, 4-27d, and 4-34d).

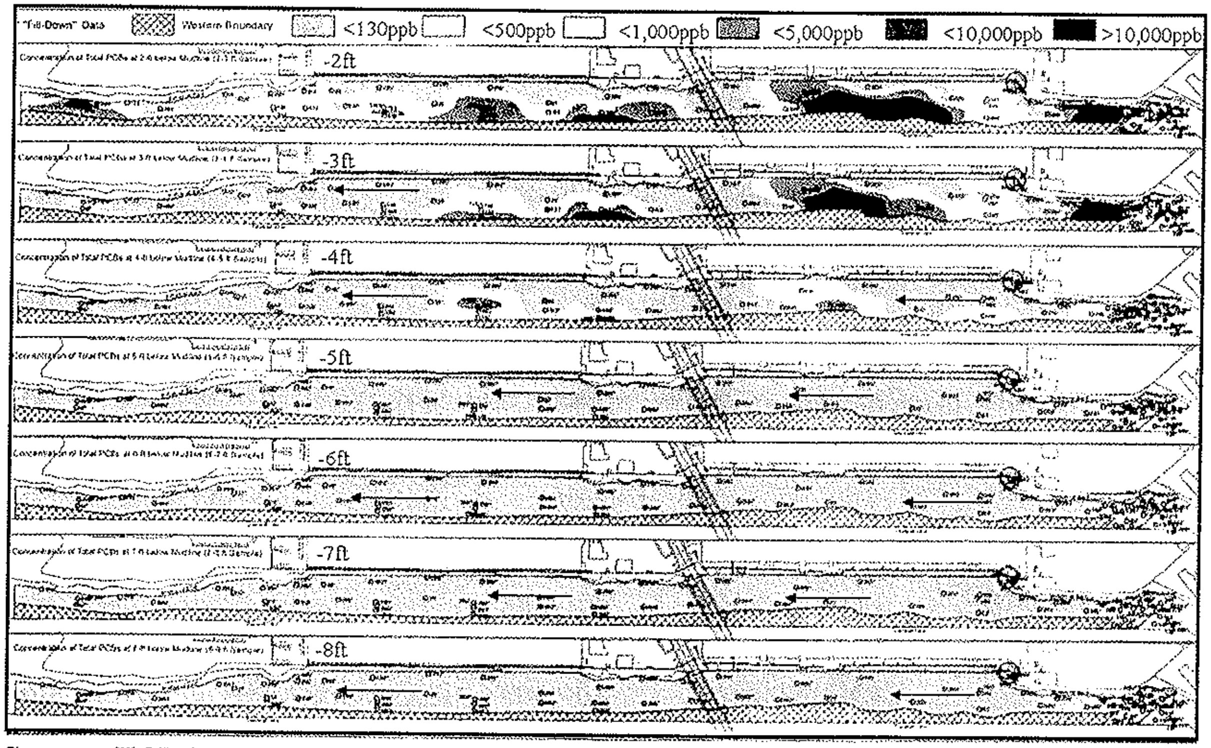
Table 4. Median and 95th percentile concentrations; comparison with marine and freshwater sediment quality standards and clean-up levels.

| Chemical Parameter | Median / 95th Percentile Concentration[a] | WA Marine[b] SQSs / CSLs | Interim SQGs[c] (TEL / PEL) | MTCA Level A[d] |
|---|---|---|---|---|
| **Metals** (mg/kg <u>or</u> parts per million) | | | | |
| Copper | 46 / 350 | 390 / 390 | 36 / 197 | --- |
| Lead | 44 / 1,900 | 450 / 530 | 35 / 91 | 250 |
| Zinc | 141 / 1,200 | 410 / 960 | 123 / 315 | --- |
| **PAHs** (µg/kg <u>or</u> parts per billion) | | | | |
| Acenaphthene | 85 / 220 | 16,000 | --- | --- |
| Anthracene | 81 / 290 | 220,000 | --- | --- |
| Benzo(a)anthracene | 140 / 940 | 110,000 | 32 / 385 | --- |
| Benzo(a)pyrene | 145 / 920 | 99,000 | 32 / 782 | 100 |
| Benzo(b)fluoranthene | 180 / 1,700 | 230,000* | --- | --- |
| Benzo(g,h,i)perylene | 110 / 440 | 31,000 | --- | --- |
| Benzo(k)fluoranthene | 150 / 1,200 | 230,000* | --- | --- |
| Chrysene | 220 / 1,600 | 110,000 | 57 / 862 | --- |
| Dibenzo(a,h)anthracene | 84 / 240 | 12,000 | --- | --- |
| Fluoranthene | 350 / 2,300 | 160,000 | 111 / 2,355 | --- |
| Fluorene | 84 / 170 | 23,000 | --- | --- |
| Indeno(1,2,3-c,d)pyrene | 110 / 520 | 34,000 | --- | --- |
| Phenanthrene | 150 / 1,200 | 100,000 | 42 / 515 | --- |

| Chemical Parameter | Median / 95th Percentile Concentration[a] | WA Marine[b] SQSs / CSLs | Interim SQGs[c] (TEL / PEL) | MTCA Level A[d] |
|---|---|---|---|---|
| Pyrene | 330 / 2,200 | 1,000,000 | 53 / 875 | --- |
| **Continued next page…** **PCBs** (µg/kg or parts per billion) | | | | |
| Aroclor-1248 | 61 / 1,015 | --- | --- | --- |
| Aroclor-1254 | 240 / 3,367 | --- | --- | --- |
| Aroclor-1260 | 445 / 8,000 | --- | --- | --- |
| Total PCBs | 663 / 10,200 | 12,000 | 34 / 277 | 1,000 |

Sources: [a]Herrera 2007; [b]WAC 173-204-320 / 520 (CSLs reported for metals only); [c]MacDonald *et al.* 2000, Smith *et al.* 1996; [d]WAC173-340-900

Figure 6. Total PCB concentrations at seven sample depths along the South Park reach.




Source: KCDOT pers. comm. 2008

The KCDOT, WSDOT-H&LP, and FHWA have concluded that sediments within 10 vertical ft of the channel bed or bottom are contaminated, that sediments between 10 and 18 ft below the channel bed or bottom are presumed contaminated until testing demonstrates otherwise, and that sediments and native substrate more than 18 ft below the channel bed or bottom are presumably uncontaminated (KCDOT 2009). These conclusions are consistent with the findings of the Remedial Investigation completed by the LDWG for the Lower Duwamish Waterway Superfund Site (LDWG 2007, pp. 267-268, Maps 4-20d, 4-27d, 4-34d, and 4-59). Reach 2, including the South Park reach, may be characterized as depositional, and while historically contaminated sediment has and is now being buried by relatively less contaminated sediment, almost all cores exhibit the highest Total PCB and carcinogenic PAH concentrations within the uppermost 8 feet of accumulated bottom sediment. Throughout much of the reach (i.e., for 79 percent of cores) patterns of Total PCB concentration as a function of depth are consistent with net sedimentation rates and the assumed peak usage of PCBs; some areas (i.e., for 21 percent of cores) exhibit the highest Total PCB concentrations at shallower depths than expected. It would appear that the highest Total PCB concentrations should be found at depths considerably less than 18 feet below the channel bed or bottom.

The draft Remedial Investigation report prepared by the LDWG finds that baseline risks to most ecological receptors are "low". Throughout as much as 75 percent of the study area or site, sediment chemistry and toxicity tests suggest that adverse effects are not likely (LDWG 2007, p. 537). However, more than three dozen contaminants of concern present a risk of adverse effects to the "base of the lower Duwamish Waterway food web" (i.e., benthic invertebrate community) throughout approximately 7 percent of the area (including the Boeing Plant 2 / Jorgensen Forge EAA), and the risk of adverse effects to these same biota are uncertain for 18 percent of the area. Consumption of clams and other shellfish from the lower Duwamish Waterway is "unsafe because of elevated PCB concentrations", and the report's finding of a measurable baseline risk of adverse effects to some species of higher trophic status (e.g., resident fish, river otters) is noteworthy (LDWG 2007, pp. 534-537).

<u>Status of the Species in the Action Area</u>

The action area contains FMO habitat for bull trout (lower Green River FMO and Puget Sound Marine FMO). FMO habitat is important for maintaining a diversity of life history forms and for providing access to productive foraging areas (USFWS 2004). The lower Duwamish River plays an important role as a migratory corridor linking the Green River and its tributaries to nearshore marine waters of the Puget Sound. As transitional habitat between the freshwater and saltwater environments, lowermost portions of the Duwamish River (or Duwamish Waterway) provide habitats where outmigrating juvenile salmon and in-migrating adult salmon adjust physiologically to changing surface water salinities and chemistry. The waters within the action area, including nearshore marine waters of Elliot Bay, support a prey base important to anadromous bull trout of the Puget Sound Management Unit.

Migratory bull trout use nonnatal watersheds (habitat located outside of their spawning and early rearing habitat) to forage, migrate, and overwinter (Brenkman and Corbett 2003a,b *in* USFWS 2004). Anadromous adult and subadult bull trout are known to occur in the action area, and presumably originate from the local populations of the Puyallup River, Snohomish-Skykomish River, and Skagit River core areas. Current information, while incomplete, suggests that the Green River does not support local bull trout populations, spawning, or rearing (USFWS 2004), and suitable bull trout spawning and rearing habitats are not present in the action area. The Puyallup River and Snohomish-Skykomish River core areas are located in relatively close proximity to the action area. The Snohomish-Skykomish River and Skagit River core areas support robust local populations, including a significant anadromous component. For these reasons, most bull trout using the lower Duwamish River and nearshore marine waters of Elliot Bay are likely to originate from these cores areas and local populations. Adult and subadult bull trout may occupy these waters at any time of year, but information is not available to reliably estimate the number of bull trout that forage, migrate, and overwinter in the action area.

Historically, bull trout were reported to use the Duwamish River and lower Green River in "vast" numbers (Suckley and Cooper 1860). In contrast, bull trout are observed infrequently in this system today. Prior to the permanent redirection of the Stuck River (lower White River) into the Puyallup River system in 1906 (Williams *et al.* 1975), the lower Green River system provided habitat for the spawning populations from the White River. Another factor that may have diminished the Green-Duwamish River system's value for bull trout is the loss of the Black River due to construction of the Lake Washington Ship Canal in the mid-1910's. The Black River historically connected the Lake Washington Basin and Cedar River to the Green-Duwamish River system. Creation of the ship canal and Ballard Locks lowered Lake Washington by 2.7 meters (9 ft) and completely redirected flows of the Cedar River and Lake Washington tributaries to the canal (Warner 1996). The effect of these diversions was to leave the Green-Duwamish River system with only about a third of its original watershed (Parametrix and NRC 2000). Potentially this may have led to a reduction in its value for bull trout foraging and colonization.

Regardless, in recent times bull trout have been reported on the lower Green River as far upstream as the mouth of Newaukum Creek at approximately river mile 41, and are consistently reported in the lower Duwamish (Kerwin and Nelson 2000; Berge and Mavros 2001; KCDNRP 2002). It is presumed that bull trout utilize the Green River up to the City of Tacoma's Headworks Diversion Dam at river mile 61, which has been a barrier to upstream migration since 1912 (Kerwin and Nelson 2000). It is not known for certain whether the bull trout observed in the lower Green River basin are foraging individuals from other core areas or if natural reproduction may still persist somewhere within the basin. Based on observed behavior from other systems within the management unit and the size of individuals typically reported, there is a strong likelihood that bull trout in the lower Green River are anadromous migrants from other core areas. Reports of historical use of tributaries in the lower Green River are rare, and there have been no recent observations (Kerwin and Nelson 2000). Given their size and potential as a foraging area, tributaries such as Newaukum and Soos Creeks may occasionally be used by bull trout.

Bull trout occurrence in the Duwamish River has been documented several times over the past few decades. In April 1978, Dennis Moore, Hatchery Manager for the Muckleshoot Tribe, talked with three fishermen in the vicinity of North Wind Weir, river mile 7 of the Duwamish, and identified four fish as adult char (Brunner, in litt. 1999a). One adult bull trout was observed near Pier 91 in May 1998 (Brunner, in litt. 1999b). In 2000, eight subadult bull trout were captured in the Duwamish River at the head of the navigation channel at the Turning Basin restoration site at river mile 5.3. These fish averaged 299 millimeters (11.8 inches) in length and were captured in August and September (Shannon, in litt. 2001). A single subadult char (222 millimeters; 8.7 inches) was caught at this same site in September of 2002 (Shannon pers. comm. 2002). In May of 2003, a large adult bull trout (582 millimeters; 23 inches) was captured in the lower Duwamish River at Kellogg Island (Shannon pers. comm. 2003).

It is not known whether bull trout historically occupied habitats in the upper Green River basin. However, given their life history, it is certainly possible. Various fish sampling efforts in the upper Green River (above Howard Hansen Dam) have not detected bull trout (Kerwin and Nelson 2000). The City of Tacoma has proposed to construct a trap and haul facility at the Headworks Diversion Dam to allow fish passage to the upper watershed as part of their habitat conservation plan. Although uncertain, it is possible that a bull trout population may become established or reestablished in the upper watershed once this facility is constructed. Establishing a self-sustaining population in the Green River system would help maintain bull trout distribution within the southern portion of the Puget Sound Management Unit. The recovery team currently identifies the upper Green River, above the Headworks Diversion Dam, as a research needs area.

Status of Critical Habitat in the Action Area

The lower Duwamish River and nearshore marine waters of Elliot Bay are designated as critical habitat for bull trout (Unit 28 – Puget Sound) [70 FR 56212 (September 26, 2005)]. The waters within the action area, including tidally-influenced wetlands below MHHW, contain seven of the eight PCEs that define bull trout critical habitat [70 FR 56212 (September 26, 2005)]. The baseline conditions of each PCE in the action area are described below. Each PCE was also described in a previous section (see Status of Critical Habitat).

1. *Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32 to 72 °F (0 to 22 °C) but are found more frequently in temperatures ranging from 36 to 59 °F (2 to 15 °C). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.*

   The lower Duwamish River frequently experiences elevated surface water temperatures during summer months. Studies conducted during 2001 and 2002 recorded a maximum surface water temperature of 21 degrees Celsius at the South Park Marina (KCDOT 2008). Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of most years.

2. *Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and in-stream structures.*

The lower Duwamish River exhibits greatly reduced instream habitat complexity and diversity. Throughout the action area the river and its floodplain are very heavily developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other related activities (LDWG 2009a). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact today (Kerwin and Nelson 2000). The action area exhibits fragmented and heavily degraded riparian conditions, extensive bank hardening and channelization, a fairly uniform U-shaped channel, degraded substrate conditions, greatly diminished pool, refuge, and off-channel habitat, and a great many and wide variety of artificial overwater structures and encumberances. Instream habitat function and complexity is substantially diminished compared to historic conditions.

4. *A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.*

The hydrology of the lower Duwamish River has been substantially altered from historic conditions through diversion of the Stuck River (lower White River), Black River, and Cedar River early in the last century. The effect of these diversions was to leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000). Today the lower Duwamish River exhibits reduced base flows. The floodplain is very heavily developed and no doubt contributes to an altered storm hydrograph (i.e., "flashy" peak flows).

5. *Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.*

Throughout the action area the river and its floodplain are very heavily developed. Less than 2 percent of the lower Duwamish River's intertidal wetland remains intact today (Kerwin and Nelson 2000). This loss of floodplain connectivity and wetland function contributes to low base flow conditions and elevated surface water temperatures. However, it is unclear how springs, seeps, and other groundwater sources historically contributed to water quality at this low position in the watershed.

6. *Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.*

The lower Duwamish River's proper function as a migratory corridor is greatly diminished. Elevated surface water temperatures, extensive sediment and surface water contamination, loss of floodplain connectivity and altered hydrologic conditions (including low base flows), degraded riparian conditions, extensive bank hardening and channelization, degraded substrate conditions, loss of pool, refuge, and off-channel habitat, and a great many and wide variety of artificial overwater structures and encumberances present physical, biological, and water quality impediments to free movement.

7. *An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.*

   Despite heavily degraded flooplain, riparian, and instream habitat conditions, the lower Duwamish River still supports salmon and steelhead of the Green-Duwamish watershed. These populations of Chinook, chum, and coho salmon, steelhead, and sea run coastal cutthroat trout, as well as other native and non-native fishes, provide a sizable prey base for adult and subadult bull trout. However, sediments and surface water are contaminated throughout large portions of the lower Duwamish River and these present an ongoing threat to the health of the benthic invertebrate community and food web in general (LDWG 2007, pp. 534-537). Sources of terrestrial prey are greatly diminished.

8. *Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.*

   Throughout the action area the river, its floodplain, and intertidal wetlands are very heavily developed. Diversions leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000). This loss of floodplain connectivity, wetland function, and natural hydrology contributes to low base flow conditions and elevated surface water temperatures. Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of most years. Sediments and surface water are contaminated throughout large portions of the lower Duwamish River and these present an ongoing threat to the health of the benthic invertebrate community and food web in general (LDWG 2007, pp. 534-537). Water quantity and quality conditions are degraded throughout the action area and limit normal bull trout reproduction, growth, and survival.

<u>Effects of Past and Contemporaneous Actions</u>

Throughout the action area the lower Duwamish River and its floodplain are very heavily developed. Since the late 1800s these portions of the lower Duwamish River have been the focus of a long succession of flood control, navigational, port, industrial, and other related activities (LDWG 2009a). Less than 2 percent of the lower Duwamish River's pre-development estuarine mud flat, sand flat, and intertidal wetland remains intact today (Kerwin and Nelson 2000), and hydrology has been substantially altered from historic conditions through diversion of the Stuck

River (lower White River), Black River, and Cedar River. The effect of these diversions was to leave the Green-Duwamish River system with only a third of its original watershed (Parametrix and NRC 2000).

The EPA has placed a large portion of the lower Duwamish River onto the "Superfund" List (WDOE 2009a). Sources of toxic surface water and sediment contamination, and the feasibility of various source control and corrective actions, have been the focus of intensive study since the mid-1970s (LDWG 2009a). Corrective actions began as early as the 1950s and 60s, and continue to the present. The LDWG, EPA, and WDOE are planning and administering clean-up and other remedial actions at various stages of completion throughout the lowermost six miles.

The quality and amount of FMO habitat available to bull trout along the lower Duwamish River, and its proper function as a migratory corridor, are today greatly diminished. Degraded floodplain and riparian conditions, loss of instream habitat complexity and function, and impaired surface water and sediment quality present physical, biological, and water quality impediments to free movement and limit normal bull trout reproduction, growth, and survival.

The FWS has previously issued Opinions and granted incidental take for more than two dozen actions adversely affecting bull trout of the Puyallup River, Snohomish-Skykomish River, or Skagit River core areas. The FWS determined that each of these actions is not likely to jeopardize the continued existence of bull trout and will not destroy or adversely modify designated bull trout critical habitat. Nevertheless, the combined effects of these past and contemporaneous Federal actions have resulted in short- and long-term adverse effects to bull trout and, in some instances, an incremental degradation of the environmental baseline.

Other past and contemporaneous actions with particular relevance include completed and on-going source control, clean-up, and remedial actions to address toxic soil, surface/groundwater, and sediment contamination. Presumably, sources of contamination are now much reduced and completed actions have made some progress in lessening exposure and effects to the lower Duwamish River ecosystem. However, several large and heavily-contaminated sites, among them the Boeing Plant 2 / Jorgensen Forge EAA, have not yet benefited from planned, comprehensive clean-up actions. The LDWG, EPA, and WDOE expect that these actions will be ongoing for many years into the future.

## EFFECTS OF THE ACTION (Bull Trout and Designated Critical Habitat)

This section addresses the direct and indirect effects of the proposed action and its interrelated and interdependent activities. The regulations implementing the Act define "effects of the action" as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline" (50 CFR section 402.02).

The proposed action is expected to result in both direct and indirect effects to bull trout and to designated bull trout critical habitat. These effects will be temporary and limited in both physical extent and duration. The following effects analysis addresses these effects, as well as any potential effects associated with interrelated and interdependent actions.

The proposed action is expected to have measurable adverse effects to bull trout and designated bull trout critical habitat. Construction will directly affect instream habitat that supports bull trout and bull trout may be present at the time of construction. While work conducted below MHHW would be completed during the established in-water work window, exposure of adult and subadult bull trout to construction activities is not discountable. Bull trout will be exposed to elevated underwater SPLs resulting from pile installation, to elevated levels of turbidity, re-suspended river sediments contaminated (or potentially contaminated) with metals, PAHs, and PCBs, and to elevated water column concentrations of these same hazardous contaminants resulting from sediment re-suspension, release of contaminated interstitial pore water, and/or discharge of treated return water.

Pile driving and proofing with an impact hammer(s) has the potential to kill or injure a limited number of adult and subadult bull trout. Pile driving and proofing may also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter) to a distance of approximately 8,200 ft downstream and 2,350 ft upstream of piling installation operations. Pile driving and proofing with an impact hammer may temporarily cause bull trout to avoid the action area, impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

The proposed action includes more than three full seasons of in-water work within the lower Duwamish River and adjacent tidally-influenced wetlands. Work may temporarily degrade surface water quality and thereby significantly disrupt normal bull trout behaviors. These activities include placement of temporary piles and construction of temporary work trestles, placement of temporary sheet pile cofferdams, construction of the new caisson foundations, bascule piers, and pier protection piles, demolition and removal of the existing piers and protection piles, removal of temporary piles, work trestles, and cofferdams, and barge operations. Activities that significantly disrupt normal bull trout behavior may cause bull trout to avoid the action area, impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

The proposed action includes in-water work within contaminated portions of the lower Duwamish River. These activities present a risk of exposing bull trout to sediments and water contaminated with metal, PAH, and PCB concentrations sufficient to cause measurable adverse effects. In particular, several of the PAHs, and to a lesser extent several of the PCBs, are present at sediment concentrations which, if re-suspended and allowed to desorb to the surrounding water column, may cause adverse effects to acutely exposed fish. Exposure concentration and duration would strongly influence whether acute exposures are likely to cause lethal or sub-lethal effects. Whether exposed bull trout may suffer lethal or sub-lethal effects (e.g., reduced growth, reproductive fitness, or long-term survival) is difficult to determine with available information. However, the best available science leads the FWS to conclude, with a high degree of certainty, that acute contaminant exposures resulting from the proposed action will cause measurable adverse effects. When present in the water column at elevated levels, these contaminants may also significantly disrupt normal bull trout behaviors. Acute contaminant exposures resulting from sediment re-suspension, release of contaminated interstitial pore water, and/or discharge of treated return water will be limited in duration and extent, but some of the anticipated effects (e.g., reduced growth or reproductive fitness) will last for the lives of the exposed individuals and there is at least some risk of a limited number of lethal exposures.

Construction activities present a risk of directly mobilizing and transporting bottom sediments contaminated with toxic metals, PAHs, and PCBs. The proposed action will also permanently alter hydraulics and channel bed dynamics in the vicinity of the new and existing bascule piers, and may indirectly cause or contribute to post-construction channel bed scour and mobilization of additional contaminated bottom sediment later in time. We expect that the proposed action will mobilize and transport metal, PAH, and PCB contamination downstream of the project area and, in the short-term, measurably alter patterns of contaminant exposure along some portions of the lower Duwamish River. We expect measurable short-term adverse effects to bull trout habitat and the bull trout prey base. However, in the long-term we expect that the pattern and severity of chronic contaminant exposures and effects to bull trout, their habitat, and prey base will not be measurably altered. We expect that the proposed action will not cause permanent changes to the pattern or severity of chronic contaminant exposures within the action area. No measurable, incremental long-term or permanent effects to bull trout, their habitat, or prey base are expected.

The proposed action will have temporary adverse effects to designated bull trout critical habitat, including PCEs #2 (*Complex Stream Channels*), #6 (*Migratory Corridors With Minimal Impediments*), #7 (*Food Base*), and #8 (*Water Quantity and Quality*). The net permanent increase in fill volume and area below MHHW is negligible, the proposed stormwater design will have no measurable long-term effects to surface water quality or hydrology, and the action will not cause measurable permanent changes to the pattern or severity of chronic contaminant exposures within the action area.

<u>Insignificant and Discountable Effects</u>

Some of the proposed action's potential effects to bull trout and designated bull trout critical habitat are/will be insignificant or discountable. Effects to bull trout resulting from the following items of work are considered extremely unlikely to occur (discountable) or will not be measurable or detectable (insignificant):

- Placement of a sand blanket to reduce sediment re-suspension during construction.
- Placement of temporary steel piles and sheet piles below MHHW of the lower Duwamish River with the use of a vibratory hammer, or by direct pushing.
- Removal of temporary steel piles and sheet piles by direct pulling, extraction with the use of a vibratory hammer, or a combination of methods.
- Excavation and pouring of concrete below MHHW of the lower Duwamish River, when conducted in isolation from flowing waters.

- Miscellaneous activities, including placement of compaction grouting, installation of "earthquake drains" to mitigate soil liquefaction, directional boring and placement of a submarine cable between the new bascule piers, and on-site shallow water and shoreline restoration and enhancement activities.

In order to reduce the amount of sediment that may be re-suspended during construction, the project will place an approximately 6 to 12-inch blanket of clean granular material prior to or during installation of temporary work trestles/piles and cofferdams. The sand blanket will cover an area below MHHW as large as 35,000 $ft^2$ (0.8 acre) and will differ in character from the native substrates. The project does not propose to remove the sand blanket. The FWS expects that this material will be removed at a later date as part of a future clean-up or remedial action conducted within the reach.

The placed sand blanket will reduce the amount of re-suspended sediment and associated contamination. This item of work will have important, short-term benefits for bull trout. However, the sand blanket will cover a large area and the FWS does expect it will have measurable, temporary effects to the benthic community inhabiting these native substrates. Placement of a sand blanket to reduce sediment re-suspension during construction will have no measurable short- or long-term adverse effects on bull trout, but may have temporary adverse effects on designated bull trout critical habitat. For a fuller description of potential effects to designated bull trout critical habitat, see a sub-section that follows (Effects to the PCEs of Designated Bull Trout Critical Habitat).

The project will place approximately 366 temporary steel piles and 179 permanent steel piles (545 steel piles in total) below MHHW. The project will also place steel sheet piles when constructing seven temporary cofferdams. All piles will be installed with a vibratory hammer, an impact hammer, direct pushing, or a combination of these methods. Temporary steel piles and sheet piles will be removed by direct pulling, extraction with the use of a vibratory hammer, or a combination of these methods. Both the installation and removal of steel piles and sheet piles will be completed during an in-water work window of August 1 to February 15.

Vibratory hammers produce, on average, underwater peak pressures that are approximately 17 dB lower than those generated by impact hammers (Nedwell and Edwards 2002). Underwater sound produced by vibratory and impact hammers differs not only in intensity, but also in frequency and impulse energy (i.e., total energy content of the pressure wave). This may explain why no documented fish kills have been associated with the use of vibratory hammers. Most of the sound energy produced by impact hammers is concentrated at frequencies between 100 and 800 Hz, across the range thought to be most harmful to exposed aquatic organisms, while sound energy produced by vibratory hammers is concentrated between 20 and 30 Hz. In addition, sound pressures produced by impact hammers rise much more rapidly than do the sound pressures produced by vibratory hammers (Carlson *et al.* 2001; Nedwell and Edwards 2002).

The site of the South Park Bridge, where temporary piling would be placed and removed with a vibratory hammer, is located in a large river system where currents contribute substantially to ambient levels of underwater sound. We expect that underwater sound produced when placing steel piles and sheet piles with a vibratory hammer, and when removing these piles, will not be detectable to a significant distance and that bull trout present within the action area will not be injured as a result of these operations. Similarly, we expect that any related, temporary effects to normal bull trout behaviors (i.e., ability to successfully feed, move and/or shelter) will not be measurable and are therefore insignificant.

The project will use temporary steel sheet pile cofferdams, sealed to minimize exchange with the surrounding water column, when constructing the new caisson foundations and bascule piers, and when demolishing and removing the existing piers. These activities, including excavation and pouring of concrete, will be isolated from flowing water. Therefore, effects to bull trout and designated bull trout critical habitat resulting from this work are considered extremely unlikely and are therefore discountable.

Placement of compaction grouting, and directional boring and placement of a submarine cable between the new bascule piers, will be completed below the channel bed. This work will not breach the channel bottom, or otherwise affect water quality or substrate conditions in the lower Duwamish River. Effects to bull trout and designated bull trout critical habitat resulting from this work are considered extremely unlikely and are therefore discountable.

The project will install "earthquake drains" to mitigate soil liquefaction in the event of seismic instability. A dense field of vertical, perforated drain pipes will be installed below ground in the vicinity of the new bridge abutments. These structures will not alter patterns of surface or groundwater flow and will not cause or contribute to the movement of site contamination (KCDOT 2009). Effects to bull trout and designated bull trout critical habitat resulting from this work are considered extremely unlikely and are therefore discountable.

The project will complete in-water work to restore and enhance left-bank shallow water, shoreline, and riparian zones in the immediate vicinity of the new bridge. This work will have beneficial effects for bull trout and designated bull trout critical habitat, and no measurable adverse effects are expected. Effects to bull trout and designated bull trout critical habitat resulting from this work are considered insignificant.

The following direct and indirect effects are considered extremely unlikely to occur (discountable) or will not be measurable or detectable (insignificant):

- Entrapment within temporary cofferdams.
- Long-term (operational) stormwater effects to surface water quality and hydrology.

The project will use temporary steel sheet pile cofferdams when constructing the new caisson foundations and bascule piers, and when demolishing and removing the existing piers. Because relatively few bull trout are expected to occur within the action area, because these structures are small in size relative to the width of the channel, and bull trout are likely to avoid locations where over-water work with heavy equipment is on-going, we do not expect bull trout will be trapped within the cofferdams, injured, or otherwise affected by the work. Entrapment within temporary cofferdams and resulting adverse effects to bull trout are considered extremely unlikely and are therefore discountable.

The proposed stormwater design is expected to achieve measurable reductions in post-project annual stormwater loadings of TSS, total Cu, and total and dissolved Zn, and will also measurably reduce post-project treated effluent/discharge concentrations for each pollutant (KCDOT 2009). The project will influence patterns of runoff and infiltration on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph within the project's receiving waters. The proposed stormwater design is not expected to cause or contribute to measurable increases in surface water temperature, and will not degrade thermal refugia within the action area. With full implementation of the proposed conservation measures and permanent design elements, we expect that the project's potential long-term, indirect effects to surface water quality and hydrology will not be measurable to any significant distance beyond the points of stormwater discharge. We expect that the proposed stormwater design will have no measurable effects on bull trout and designated bull trout critical habitat. As such, we conclude that long-term (operational) stormwater effects on bull trout and designated bull trout critical habitat will be insignificant.

Adverse Effects of the Action

*Exposure to Elevated Underwater Sound Pressure Levels*

Pile driving and proofing with an impact hammer(s) has the potential to kill or injure a limited number of adult and subadult bull trout. Pile driving and proofing may also significantly disrupt normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter) to a distance of approximately 8,200 ft downstream and 2,350 ft upstream of piling installation operations. Due to channel geometry, we expect that underwater sound propagation will be limited beyond the first upstream and downstream channel bends. Pile driving and proofing with an impact hammer may cause bull trout to temporarily avoid the action area, impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

The project will place approximately 366 temporary steel piles and 179 permanent steel piles (545 total) below MHHW (KCDOT 2009). All piles will be installed with a vibratory hammer, an impact hammer, or a combination, as site conditions allow. Most or all of the load-bearing piles will be proofed with an impact hammer. Except when driving test piles to determine baseline SPLs, the project will conduct all impact pile driving operations with the use of a noise attenuation device (i.e., confined bubble curtain, temporary noise attenuation pile, or functional equivalent). Pile driving equipment may operate from the temporary work trestles, barges, and/or floating platforms.

All pile driving and proofing will be conducted during the in-water work window (August 1 to February 15). Pile driving and proofing with an impact hammer(s) will be intermittent, alternating or concurrent with use of a vibratory hammer and other work. The project may place as many as eight piles per day, but the tentative construction schedule also suggests that pile installation will require as many as 100 working days (KCDOT 2009).

Effects of Elevated Underwater SPLs - General

High underwater SPLs are known to have negative physiological and neurological effects on a wide variety of vertebrate species (Yelverton *et al.* 1973; Yelverton and Richmond 1981; Turnpenny and Nedwell 1994; Hastings and Popper 2005). High underwater SPLs are known to injure and/or kill fishes, as well as cause temporary stunning and alterations in behavior (Turnpenny and Nedwell 1994; Turnpenny *et al.* 1994; Popper 2003; Hastings and Popper 2005). Risk of injury appears related to the effect of rapid pressure changes, especially on gas-filled spaces in the bodies of exposed organisms (Turnpenny *et al.* 1994). Fish-kills have been among the most noticeable and well-documented adverse effects of in-water impact pile driving. With few exceptions, however, fish-kills are generally reported only when dead or injured fish are observed at the surface and therefore the frequency and magnitude of such kills are likely underestimated. High underwater SPLs can also cause a variety of behavioral responses, many of which have not been thoroughly studied.

The effects of elevated underwater SPLs on exposed organisms can vary substantially, ranging broadly from no noticeable effect to instantaneous mortality. Over this continuum of effect, there is no easily identifiable point at which behavioral responses transition to physical effects. We evaluated two types of exposure to elevated SPLs, those causing injury and/or mortality, and those causing significant behavioral responses or disruption.

Effects of Elevated Underwater SPLs - Injury and Mortality

Injury and mortality in fishes has been attributed to impact pile driving (Stotz and Colby 2001; Stadler 2002; Abbott *et al.* 2005; Hastings and Popper 2005). The injuries associated with exposure to high SPLs are referred to as barotraumas, and include hemorrhage and rupture of internal organs, hemorrhaged eyes, and temporary stunning (Yelverton *et al.* 1973; Yelverton *et al.* 1975; Yelverton and Richmond 1981; Turnpenny and Nedwell 1994; Hastings and Popper 2005). Death as a result of barotrauma can be instantaneous, occurring within minutes after exposure, or can occur several days later (Abbott *et al.* 2002). Necropsy results from Sacramento blackfish (*Othodon microlepidotus*) exposed to high SPLs showed fish with extensive internal bleeding and a ruptured heart chamber were still capable of swimming for several hours before death (Abbott *et al.* 2002). Sub-lethal injuries can interfere with the ability to carry out essential life functions such as feeding and predator avoidance (Popper 2003).

The potential for injury and/or mortality depends on several factors, including the type of sound and intensity of sound produced. These, in turn, are strongly influenced by the type of hammer, characteristics of the substrate and subsurface conditions, depth of water, and the presence or absence of channel (bed and bank) formations that might serve to naturally intercept and attenuate SPLs. Firmer substrates are more resistant to penetration, generally require more force and energy when pile driving, and therefore usually produce more intense sound pressures. In addition to the type of sound and intensity of sound produced, other factors that influence the potential for injury and/or mortality include the size of the exposed organism(s), anatomical variation, and location in the water column (Gisiner *et al.* 1998). Sound energy from an underwater source readily enters the bodies of exposed organisms because the acoustic impedance of animal tissue nearly matches that of water (Hastings 2002).

Gas-filled structures are particularly susceptible to the adverse effects of elevated underwater sound (Gisiner *et al.* 1998). Examples of gas-filled structures found in vertebrate species include swimbladders, bowels, sinuses, and lungs. As sound travels from a fluid medium into a gas-filled structure there is a dramatic drop in pressure, which can cause rupture of the hollow organs (Gisiner *et al.* 1998). This has been demonstrated in fishes with swimbladders (including salmonids). As a sound pressure wave passes through a fish, the swimbladder is rapidly compressed due to the high pressure and then rapidly expanded by the underpressure. Exposure to this type of "pneumatic pounding" can cause rupture of capillaries in the internal organs, as observed in fishes with blood in the abdominal cavity, and maceration of kidney tissues (Abbott *et al.* 2002; Stadler 2002).

Yelverton and Richmond (1981) and Yelverton *et al.* (1973) exposed a variety of fish species, various birds, and terrestrial mammals to underwater explosions. Common to all the species were injuries to air- and gas-filled organs, as well as eardrums. These studies identified injury thresholds in relation to the size of the charge, the distance at which the charge was detonated, and the mass of the exposed animal. Yelverton *et al.* (1973) and Yelverton and Richmond (1981) found that the greater the fish's mass, the greater impulse level needed to cause an injury. Conversely, a fish with smaller mass would sustain injury from a smaller impulse.

At Bremerton, Washington, approximately 100 surfperch (*Cymatogaster aggregata, Brachyistius frenatus* and *Embiotoca lateralis*) were killed during impact driving of 30-inch diameter steel pilings (Stadler 2002). The size of these fish ranged from 70 mm to 175 mm fork length. Dissections revealed that the swimbladders of the smallest of the fishes (80 mm fork length) were completely destroyed, while those of the largest individual (170 mm fork length) were nearly intact. Damage to the swimbladder of *C. aggregata* was more severe than to similar-sized *B. frenatus*. These results are suggestive of size and species-specific differences and are consistent with those of Yelverton *et al.* (1975) who found size and/or species differences in injury from underwater explosions.

Another mechanism of injury and mortality resulting from high SPLs is "rectified diffusion", or the formation and growth of bubbles in tissue. Rectified diffusion can cause inflammation and cellular damage because of increased stress and strain (Vlahakis and Hubmayr 2000; Stroetz *et al.* 2001) and blockage or rupture of capillaries, arteries, and veins (Crum and Mao 1996). Crum and Mao (1996) analyzed bubble growth caused by sound signals at low frequencies (less than 5,000 Hz), long pulse widths, and atmospheric pressure. Their analysis indicates that underwater SPLs exceeding 190 $dB_{peak}$ can cause bubble growth.

Due to differences between species and from variation in exposure type and duration, uncertainty remains as to the degree of potential adverse effect from SPLs between 180 and 190 $dB_{peak}$. Turnpenny *et al.* (1994) exposed brown trout (*Salmo trutta*) to SPLs greater than 170 dB using pure tone bursts for a duration of 90 seconds. This resulted in a mortality rate of 57 percent (after 24 hours) in brown trout; 50 percent mortality (after 24 hours) was observed in bass (*Dicentrarchus labrax*) and whiting (*Merlangius merlangus*) exposed to SPLs greater than 176 dB. The authors suggest that the threshold for continuous sounds is, or ought to be, lower than for pulsed sounds, such as seismic airgun blasts. Sound pressures produced by impact pile driving are more similar to those produced by airgun blasts. As such, we conclude that the 170 dB threshold for injury to brown trout identified by Turnpenny *et al.* is likely lower than the injury threshold associated with underwater SPLs produced by impact pile driving.

Until recently, the FWS used SPLs measured as peak pressure to estimate the onset of injury. However, effective June 2008, the FWS, WSDOT, FHWA, and other signatory agencies have formally endorsed application of new interim criteria recommended by the Fisheries Hydroacoustic Working Group (June 12, 2008 MOA). These new interim criteria apply a Sound Exposure Level (SEL) framework for assessing fish injury. For further details, see a sub-section that follows (Estimate of the Extent of Effect).

Effects of Elevated Underwater SPLs - Behavioral Responses

Elevated underwater SPLs can elicit a variety of behavioral responses. In general, there is much uncertainty regarding the response of organisms to sources of underwater sound, and there are no experimental data specific to bull trout exposed to underwater sound from impact pile driving. Further confounding the issue, most of the information on behavioral effects of underwater sound is obtained from studies examining pure tone sounds. Sounds generated by impact pile driving are impulsive and are made up of multiple frequencies/tones, making comparisons with existing data difficult.

Knudsen *et al.* (1992) studied spontaneous awareness reactions (consisting of reduced heart beat frequency and opercular movements), and avoidance responses to sound in juvenile Atlantic salmon. This study evaluated responses to frequencies ranging from 5 to 150 Hz. With increasing frequency, the difference between the threshold for spontaneous awareness reaction and the estimated hearing threshold also increased. At 5, 60 and 150 Hz, the signal had to exceed the hearing thresholds by 25, 43 and 73 dB, respectively, to elicit reactions. Most of the sound energy produced by impact pile hammers is concentrated at frequencies between 100 and 800 Hz. Salmonids can detect sounds at frequencies between 10 Hz (Knudsen *et al.* 1997) and 600 Hz (Mueller *et al.* 1998). Optimal salmonid hearing is thought to be at frequencies of 150 Hz (Hawkins and Johnstone 1978). Therefore, impact pile installation produces sounds within the range of salmonid hearing.

Exposure to elevated SPLs can result in temporary hearing damage referred to as Temporary Threshold Shift (TTS). Most bioacoustic specialists consider TTS to be physiological fatigue and not injury (Popper *et al.* 2006). However, an organism experiencing TTS may be unable to detect biologically relevant sounds such as approaching predators or prey, and/or mates attempting to communicate. Mesa (1994) examined predator avoidance ability and physiological response of Chinook salmon subjected to various stressors. Test subjects were agitated to cause disorientation. When equal numbers of stressed and unstressed fish were exposed to predators, there was significantly more predation of stressed fish. Shin (1995) reports that impact pile driving may result in agitation of fish, manifested as a change of swimming behavior.

Turnpenny *et al.* (1994) attempted to determine a level of underwater sound that would elicit behavioral responses in brown trout, bass, sole, and whiting. In brown trout an avoidance reaction was observed above 150 $dB_{rms}$, and other reactions (e.g., a momentary startle) were observed at 170-175 $dB_{rms}$. The report references Hastings' "safe limit" recommendation of 150 $dB_{rms}$ and concludes that the Hastings' "safe limit" provides a reasonable margin below the lowest levels where fish injury was observed. In an associated literature review, Turnpenny and Nedwell (1994) also state that the Hastings' 150 $dB_{rms}$ limit did not appear overly stringent and that its application seemed justifiable.

More recently, Fewtrell (2003) held fish in cages in marine waters and exposed them to seismic airgun impulses. The study detected significant increases in behavioral response when sound pressure levels exceeded 158-163 $dB_{rms}$. Responses included alarm, faster swimming, tighter grouping, and movement toward the lower portion of the cage. It is difficult to discern the significance of these behavioral responses. The study also evaluated physiological stress response by measuring plasma cortisol and glucose levels and found no statistically significant changes. Conversely, Santulli *et al.* (1999) found evidence of increased stress hormones after exposing caged European bass to seismic survey noise.

Popper (2003) suggests that the behavioral responses of fishes may include swimming away from the sound source, thereby decreasing potential exposure to the sound, or "freezing" (staying in place), thereby becoming vulnerable to possible injury. Feist *et al.* (1992) found that impact pile driving affected juvenile pink and chum salmon distribution, school size, and schooling behavior. In general, on days when impact pile driving was not conducted, fish exhibited a more polarized schooling behavior (i.e., movements in a more definite pattern). On days when impact pile driving was conducted, fish exhibited an active "milling" behavior (i.e., movement in an eddying mass); fish did appear to change their distributions about the site, more commonly orienting and moving towards an acoustically-isolated cove, on days when impact pile driving was conducted. Observations by Feist *et al.* (1992) suggest that SPLs in excess of 150 $dB_{rms}$ may disrupt normal migratory behavior in juvenile salmon.

Clearly, there is a substantial gap in scientific knowledge on the topic of significant behavioral responses to elevated underwater SPLs. The most recent study by Fewtrell (2003) presents some experimental data on behavioral responses of fishes to impulsive sounds above 158 $dB_{rms}$. However, given the large amount of uncertainty that lies not only in extrapolating from experimental data to the field, but also between sound sources (airguns vs. pile driving), and from one species to another, the FWS believes it is appropriate to utilize the most conservative known threshold. As such, for the purposes of this analysis, the FWS expects that SPLs in excess of 150 $dB_{rms}$ will cause significant behavioral changes in bull trout and will or may disrupt normal bull trout behaviors (i.e., ability to successfully feed, move and/or shelter).

Estimate of the Extent of Effect

Until recently, the FWS used SPLs measured as peak pressure to estimate the onset of injury. However, effective June 2008, the FWS, WSDOT, FHWA, and other signatory agencies have formally endorsed application of new interim criteria recommended by the Fisheries Hydroacoustic Working Group (2008). These new interim criteria apply a SEL framework for assessing fish injury.

In 2004, the California Department of Transportation and FHWA convened a group of experts in the field of underwater acoustics (referred to as the Fisheries Hydroacoustic Working Group) with the intent of evaluating and refining criteria. This effort included an extensive literature review as the basis for a report on the topic (Hastings and Popper 2005) and a white paper proposing interim criteria (Popper *et al.* 2006). The Hastings and Popper report (2005) suggested a metric of SEL may be more appropriate for assessing potential injury to fishes from impact pile driving; in part, because the use of SEL allows for the summing of energy over multiple pile driving pulses, which cannot be accomplished when using peak pressure.

The new interim criteria for fish injury identify a single-strike SPL of 206 $dB_{peak}$ and 183 dB accumulated SEL for fish less than 2 grams. The interim criteria identify a single-strike SPL of 206 $dB_{peak}$ and 187 dB accumulated SEL for fish greater than 2 grams (FHWG 2008).

The FWS uses the practical spreading model (Davidson 2004) to estimate the distance from piling installation operations (R; range) at which transmission loss (TL) can be expected to attenuate SPLs and SELs to below thresholds for injury and significant behavioral interference. The calculation [TL = 15*Log(R)] assumes that sound levels decrease at a rate of 4.5 dB per doubling distance. This method also assumes that single-strike SELs less than 150 dB do not accumulate to cause injury ("effective quiet") (Stadler pers. comm. 2009).

Three scenarios are relevant to our description of potential adverse effects from the proposed impact pile driving and proofing: 1) Impact driving of a limited number of test piles without a noise attenuation device (i.e., for the purpose of determining baseline sound levels); 2) Impact driving and proofing ("full installation with an impact hammer"), consisting of approximately 12,000 pile strikes per day (8 piles at approximately 1,500 strikes per pile); and, 3) Pile driving by a combination of methods (i.e., "vibratory and impact hammers as site conditions allow"), followed by impact proofing (approximately 4,800 pile strikes per day; 8 piles at approximately 600 strikes per pile). Except when driving test piles to determine baseline sound levels, the project will conduct all impact pile driving operations with the use of a noise attenuation device (i.e., confined bubble curtain, temporary noise attenuation pile, or functional equivalent). Pile installation will require impact pile driving on as many as 100 working days (KCDOT 2009), but full installation with an impact hammer should be necessary only when working in close proximity to the existing bascule piers (i.e., 10-15 piles located within 50 feet of the existing piers). Therefore, "full installation with an impact hammer" should not be necessary on more than approximately 2 working days (Taylor pers. comm. 2009).

Based on information provided in the BA and Addendum, we assumed the project will produce an un-attenuated single-strike SPL of approximately 212 $dB_{peak}$ and 189 $dB_{rms}$ (measured at 10 meters). We also assumed that a 5 dB reduction in sound levels will be achieved with the use of a noise attenuation device (KCDOT 2008, 2009). These assumptions regarding unattenuated pressures are within the range reported in the literature for similar operations (i.e., similar methods for piling installation, similar pile diameters, etc.) (USFWS 2007).

Based on the studies and findings presented here and in previous sub-sections, we expect that adult and subadult bull trout exposed to a single-strike SPL of 206 $dB_{peak}$ or above, and/or an accumulated SEL of 187 dB will be injured or killed. We also expect that adult and subadult bull trout exposed to single-strike SPLs of 150 $dB_{rms}$ or above will or may experience a significant disruption of their normal behaviors (i.e., ability to successfully feed, move, and/or shelter). Pile driving and proofing with an impact hammer may cause bull trout to temporarily avoid the action area, impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions.

Applying the methods of analysis summarized here, impact driving of test piles may injure or kill bull trout to a distance of approximately 1,725 ft upstream and downstream of piling installation operations. Impact driving of test piles may also significantly disrupt normal bull trout behaviors to a distance of approximately 2,350 ft upstream and 8,200 ft downstream. Channel geometry will prevent underwater sound propagation much beyond the first upstream and downstream channel bends, located at approximately 2,350 ft upstream and 8,200 ft downstream. These exposures and effects are likely to occur on approximately one working day.

Applying the methods of analysis summarized here, full installation (i.e., driving and proofing) with an impact hammer may injure or kill bull trout to a distance of approximately 1,775 ft upstream and downstream of piling installation operations. Full installation with an impact hammer may also significantly disrupt normal bull trout behaviors to a distance of approximately 2,350 ft upstream and 6,060 ft downstream of piling installation operations. At these distances, channel geometry will prevent underwater sound propagation in the upstream direction only. These exposures and effects are likely to occur on a total of approximately 2 working days.

Applying the methods of analysis summarized here, pile driving by a combination of methods (i.e., vibratory and impact hammers as site conditions allow) followed by impact proofing may injure or kill bull trout to a distance of approximately 1,725 ft upstream and downstream of piling installation operations. Pile driving by a combination of methods followed by impact proofing may also significantly disrupt normal bull trout behaviors to a distance of approximately 2,350 ft upstream and 6,060 ft downstream of piling installation operations. At these distances, channel geometry will prevent underwater sound propagation in the upstream direction only. These exposures and effects are likely to occur on a total of approximately 98 working days.

The FWS expects that low numbers of foraging and migrating adult and subadult bull trout will be in the action area at the time of construction and may be exposed to elevated underwater sound levels. We expect that very few bull trout will be injured or killed, and that the number of bull trout exposed to SPLs sufficient to significantly disrupt normal bull trout behaviors will also be low. However, use of the action area may be precluded while driving and proofing with an impact hammer(s) is ongoing. Impact pile driving and proofing may impede or discourage free movement through the action area, prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Suitable bull trout spawning and rearing habitats do not occur within the action area and therefore these essential bull trout behaviors will not be exposed or affected by piling installation operations.

*Exposure to Elevated Turbidity and Sedimentation During Construction*

The proposed action includes more than three full seasons of in-water work within the lower Duwamish River and adjacent tidally-influenced wetlands. This work includes placement of temporary piles and construction of temporary work trestles, placement of temporary sheet pile cofferdams, construction of the new caisson foundations, bascule piers, and pier protection piles, demolition and removal of the existing piers and protection piles, removal of temporary piles, work trestles, and cofferdams, and barge operations. The FWS expects these activities will degrade surface water quality and result in a significant temporary disruption of normal bull trout behaviors.

Although few studies have specifically examined the issue as it relates to bull trout, increases in suspended sediment affect salmonids in several recognizable ways. The variety of effects of suspended sediment may be characterized as lethal, sublethal or behavioral (Bash *et al.* 2001; Newcombe and MacDonald 1991; Waters 1995). Lethal effects include gill trauma (physical damage to the respiratory structures), severely reduced respiratory function and performance, and smothering and other effects that can reduce egg-to-fry survival (Bash *et al.* 2001). Sublethal effects include physiological stress reducing the ability of fish to perform vital functions (Cederholm and Reid 1987), increased metabolic oxygen demand and susceptibility to disease and other stressors (Bash *et al.* 2001), and reduced feeding efficiency (Bash *et al.* 2001; Berg and Northcote 1985; Waters 1995). Sublethal effects can act separately or cumulatively to reduce growth rates and increase fish mortality over time. Behavioral effects include avoidance, loss of territoriality, and related secondary effects to feeding rates and efficiency (Bash *et al.* 2001). Fish may be forced to abandon preferred habitats and refugia, and may enter less favorable conditions and/or be exposed to additional hazards (including predators) when seeking to avoid elevated concentrations of suspended sediment.

In order to assess the suspended sediment concentrations at which adverse effects will occur and to determine the downstream extent to which these effects may extend as a result of the proposed project, the FWS used the analytical framework attached as Appendix A (USFWS 2006). This framework uses the findings of Newcombe and Jensen (1996) to evaluate the "severity-of-effect" (SEV) based on suspended sediment concentration, exposure, and duration. Factors influencing suspended sediment concentration, exposure, and duration include waterbody size, volume of flow, the nature of the construction activity, construction methods, erosion controls, and substrate and sediment particle size. Factors influencing the SEV include duration and frequency of exposure, concentration, and life stage. Availability and access to refugia are other important considerations.

The framework in Appendix A requires an estimate of suspended sediment concentration (mg/L) and exposure duration. Monitoring data collected at the WDOE station in closest proximity (WDOE 2009e) was used to determine the ratio of turbidity to suspended solids (1 NTU : 2.52 mg/L). To determine exposure duration, the FWS assumed that work below MHHW would occur 10 hours a day, for as many as 485 working days. It is important to note, the FWS expects that any measurable increases in turbidity will be short-term and episodic.

Using this approach, we expect that adverse effects to adult and subadult bull trout resulting from work conducted within the lower Duwamish River or adjacent tidally-influenced wetlands, are likely to occur under the following circumstances:

1. When background NTU levels are exceeded by 160 NTUs at any point in time.
2. When background NTU levels are exceeded by 59 NTUs for more than 1 hour, cumulatively, over a 10-hour workday.
3. When background NTU levels are exceeded by 22 NTUs for more than 7 hours, cumulatively, over a 10-hour workday.

To assess the potential extent of these effects we relied on a limited set of monitoring data collected to determine the effectiveness of BMPs and compliance with State surface water quality standards (Appendix A; Table 5). These data provide evidence that water quality standards for turbidity are exceeded in some instances, even with the use of BMPs. Based on this information and the size of the receiving waterbody, the FWS expects that suspended sediment concentrations resulting in adverse effects to bull trout are reasonably certain to occur as far as 300 ft upstream and downstream of construction activities.

The FWS expects that low numbers of foraging and migrating adult and subadult bull trout will be in the action area at the time of construction and may be exposed to elevated turbidity and sedimentation. We expect that some bull trout will avoid the in-water work area and immediate vicinity of the South Park Bridge when elevated suspended sediment concentrations result from construction activities. Resulting turbidities may also impede or discourage free movement through the action area, may prevent individuals from exploiting preferred habitats, and/or expose individuals to less favorable conditions. Use of the area may be precluded until suspended sediment concentrations diminish. We expect that elevated turbidity and sedimentation will result in a significant temporary disruption of normal bull trout behaviors (i.e., ability to successfully feed, move, and/or shelter). Suitable bull trout spawning and rearing habitats do not occur within the action area and therefore these essential bull trout behaviors will not be exposed to in-water work or resulting temporary effects to surface water quality.

*Acute Exposure to Hazardous Contaminants*

The proposed action includes in-water work to be conducted within contaminated portions of the lower Duwamish River. These activities present a risk of exposing bull trout to sediments and water contaminated with metal, PAH, and PCB concentrations sufficient to cause measurable adverse effects. Whether exposed bull trout may suffer lethal or sub-lethal effects (e.g., reduced growth, reproductive fitness, or long-term survival), is difficult to determine with available information, and given potential contingencies and uncertainties. However, the best available science leads the FWS to conclude with a high degree of certainty, that acute contaminant exposures resulting from the proposed action will cause measurable adverse effects to bull trout.

The FWS relies on toxicity data for other salmonids when information specific to bull trout is not available. Due to taxonomic similarity, species in the Salmonidae family are considered better surrogates for bull trout than non-salmonids. However, Hansen *et al.* (2002) demonstrate that even among the members of Salmonidae sensitivities to chemical contaminants and mixtures of contaminants may differ. The FWS has relied on toxicity data for species in the following preferential order: species (bull trout), genus (*Salvelinus*), family (Salmonidae). Rainbow trout (*Oncorhynchus mykiss*) are the primary freshwater fish species used by the EPA when developing toxicity data for regulatory purposes. Therefore, the majority of data available are from studies using rainbow trout as test subjects.

The most commonly reported end points in the toxicity literature are concentrations at which 50 percent of the test subjects/population died (LC50). Concentrations that result in the death of a smaller percentage of the test population (e.g., LC10) are likely to be somewhat lower. Bull trout and other salmonids would be adversely affected if exposed to contaminant concentrations with the potential to result in acute toxicity and death, if exposed to contaminant concentrations likely to cause measurable sub-lethal effects (e.g., reduced growth or reproductive fitness), or if exposed to contaminant concentrations sufficient to significantly disrupt normal behaviors.

Bottom sediments in the vicinity of the proposed bridge replacement contain a complex and variable mixture of metal, PAH, and PCB contamination (see a previous section, Environmental Baseline in the Action Area). Several of the PAHs, and to a lesser extent several of the PCBs, are present in sediments at concentrations which, if re-suspended and allowed to desorb to the surrounding water column, may cause adverse effects to acutely exposed fish. In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the exposure concentration, duration, and physical extent.

Whether acute exposures cause lethal or sub-lethal effects will be strongly influenced by the exposure concentration and duration. Information is limited and there are important sources of uncertainty. These sources of uncertainty include the actual quantity of contaminated sediment that will or may be re-suspended, the composition and contaminant concentrations in that re-suspended sediment, the quantity and chemical composition of released interstitial pore water, and the rate or degree of contaminant desorption to the surrounding water column. Additional sources of uncertainty include the effect of intermittent, episodic, or transient exposures (Burton *et al.* 2000, p. ab; Marsalek *et al.* 1999, p. 34), variations in tolerance among exposed individuals, populations, and/or species (Ellis 2000, p. 89; Hodson 1988, p. ab; Lloyd 1987, p. 502), and, the potential for additive or synergistic effects among contaminants with similar or the same modes of toxic action (Burton *et al.* 2000, p. ab; Ellis 2000, p. 88; Lloyd 1987, p. 494). Burton *et al.* (2000, p. ab) warn that traditional toxicity tests may not lead to reliable conclusions if not tailored to reflect "real-world" patterns of exposure. Lloyd (1987, pp. 492, 501) suggests that contaminants may be more toxic to salmonids when dissolved oxygen is reduced, and advises that water quality standards should apply to whole groups of contaminants with common modes of action, rather than individual contaminants.

A number of site-specific conditions will influence the spatial extent of potential exposures. Acute exposures are usually most intense in the initial mixing zone where sediment re-suspension creates a three-dimensional plume that dissipates vertically, horizontally, and longitudinally (Bridges *et al.* 2008, pp. 6-8, 15, 18). The size and shape of the temporary plume, and therefore the spatial extent of potential contaminant exposures, will be influenced by the following: the quantity and chemical composition of re-suspended sediment, the quantity and chemical composition of released interstitial pore water, the rate or degree of contaminant desorption to the surrounding water column, particle size and resettling rate, discharge volume, current, tidal flux, degree of turbulence, height of release to the water column, sheer stress at the channel bottom, water temperature and salinity, and operational considerations (Bridges *et al.* 2008, pp. 5, 7-9, 13, 20, 42).

Without the information needed to definitively model the spatial component of potential exposures, we relied on best professional judgment and a number of simplifying assumptions. Instantaneous partitioning and equilibrium of the sediment and water column contaminant concentrations is our most important "worst-case" assumption (Bridges *et al.* 2008, pp. 22, 37; Herrera 2007, pp. 8, 10; KCDOT 2008). Under most conditions where sediment re-suspension and contaminant desorption to the water column determine exposure, equilibrium partitioning will not be achieved (Bridges *et al.* 2008, p. 18; Herrera 2007, pp. 10). Therefore, by assuming that instantaneous partitioning and equilibrium will occur, we may overestimate (but we are not likely to under-estimate) the size or intensity of the resulting contaminant plume.

Empirical evidence suggests that contaminant plumes resulting from dredging generally transition from "near field zone" processes (including potential acute exposures), to "far-field zone" processes within 100 meters of the operation (Bridges *et al.* 2008, p. 7). Any temporary contaminant plume created by the proposed action is likely to be far smaller, and less intense, than those typically resulting from channel bed dredging. Accordingly, and consistent with the BA and Addendum submitted by the FHWA (KCDOT 2008, 2009), we expect that the contaminant plume will not span the entire channel at any one time, and will occupy only a small portion of the action area. Furthermore, we expect that acute contaminant exposures with the potential to cause measurable adverse effects to bull trout will be confined to the same area where suspended sediment concentrations are temporarily elevated over ambient, background conditions (i.e., to a distance of approximately 300 ft upstream and downstream of construction activities, depending upon direction of tidal flux).

Acute contaminant exposures resulting from sediment re-suspension, release of contaminated interstitial pore water, and/or discharge of treated return water will be limited in duration and extent, but some of the anticipated effects (e.g., reduced growth or reproductive fitness) will last for the lives of the exposed individuals. There is at least some risk of lethal exposures for a limited number of bull trout. Contaminants released to the water column may also significantly disrupt normal bull trout behaviors.

Metals

Median metal sediment concentrations in the vicinity of the proposed bridge replacement exceed TELs, and the 95th percentile concentrations approach or exceed SQSs, CSLs, PELs, and MTCA Level A (Herrera 2007). However, as discussed below, predicted equilibrium water column concentrations (i.e., dissolved metal concentrations in any resulting contaminant plume) are low (see Estimate of Exposure Concentration, Duration, and Extent). Sandahl *et al.* (2007) documented sensory physiological impairment in juvenile coho, and related disruption to predator avoidance behaviors, at concentrations as low as 2 μg/L dissolved copper. Sprague (1968) found that at concentrations as low as 5.6 μg/L dissolved zinc juvenile rainbow trout exhibit avoidance behavior. By comparison, predicted equilibrium concentrations in any resulting contaminant plume are approximately 1.31 μg/L dissolved copper and 1.15 μg/L dissolved zinc (Herrera 2007). We do not expect that temporary exposure to these dissolved metal concentrations will adversely affect bull trout, either individually or additively.

Polycyclic Aromatic Hydrocarbons (PAHs)

The PAHs are a class of organic chemical compounds, consisting of fused aromatic rings, commonly found in oil, coal, and tar and frequently occurring in nature as a byproduct of fuel burning and/or incomplete combustion. As an environmental contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they show an apparent tendency for bioaccumulation (EPA 2009d). Many of the PAHs are potent carcinogens, and a host of other (i.e., non-cancer-causing) potential biological effects are poorly understood. In aquatic systems, the high-molecular weight PAHs tend to exhibit greater toxicity than do the low-molecular weight PAHs. The toxicological literature reports inhibited reproduction, delayed emergence, liver disease or malfunction, morphological abnormalities, immune system impairment, and mortality in benthic invertebrates and/or fish resulting from exposure to PAHs (EPA 2009d).

In the vicinity of the proposed bridge replacement median sediment concentrations for six PAHs exceed TELs, and the 95th percentile concentrations for five PAHs exceed PELs. Mean and 95th percentile sediment concentrations of benzo(a)pyrene, a PAH for which a MTCA Level A is available, both greatly exceed the standard. As shown below, predicted equilibrium water column concentrations for several PAHs, including anthracene, benzo(b,k)fluoranthene, fluoranthene, fluorene, phenanthrene, and pyrene, are sufficiently high to present a risk of adverse acute exposures and effects. Furthermore, because PAHs cause effects through similar modes of toxic action, any resulting contaminant plume presents a risk of toxic interaction and additive or synergistic effects in exposed bull trout.

Polychlorinated Biphenyls (PCBs)

The PCBs are a class of synthetic organic chemical compounds, consisting of 1 to 10 chlorine atoms attached to a biphenyl group (two bonded benzene rings). These compounds originate from various industrial sources and processes, including dielectric fluids in transformers and capacitors, coolants, lubricants, electrical wiring and components, pesticides, cutting oils, flame retardants, hydraulic fluids, sealants, adhesives, paints and finishes, and dust control agents (EPA 2009d). As an environmental contaminant, these compounds are of concern because of their documented carcinogenic, mutagenic, and teratogenic properties, and because they show an apparent tendency for bioaccumulation. The toxicological literature reports reduced fertilization success and egg survival, reproductive failure, reduced growth, liver malfunction, and altered blood and enzyme function in benthic invertebrates and/or fish resulting from exposure to PCBs (EPA 2009d).

The median Total PCB sediment concentration in the vicinity of the proposed bridge replacement greatly exceeds the TEL and PEL, and the 95$^{th}$ percentile sediment concentration greatly exceeds MTCA Level A. As shown below, predicted equilibrium water column concentrations for individual Aroclor PCBs are sufficiently high to present a risk of adverse acute exposures and effects. As a group of contaminants with a common mode of toxic action, PCBs (like the PAHs) also present a risk of toxic interaction and additive or synergistic effects in exposed bull trout.

Estimate of Exposure Concentration, Duration, and Extent

The BA submitted by the FHWA (KCDOT 2008) describes the potential for acute contaminant exposures resulting from temporarily elevated metal, PAH, and PCB water column concentrations. The BA relies upon methods and findings described in greater detail elsewhere (Herrera 2007).

In order to assess the potential for adverse effects stemming from acute exposures, it is necessary to know something of the exposure concentration, duration, and physical extent. Herrera (2007, pp. 6-7) applied accepted methods, many of them outlined by the EPA, and used conservative assumptions (e.g., instantaneous equilibrium partitioning) to predict the equilibrium metal, PAH, and PCB water column concentrations that might occur temporarily as a result of in-water work, related re-suspension of contaminated sediments, and desorption to the surrounding water column.

These temporarily elevated water column concentrations were then compared to Toxicity Reference Values (TRVs) obtained from the toxicological literature. Ecological TRVs are "species-specific and chemical-specific estimates of an exposure level that is not likely to cause unacceptable adverse effects on growth, reproduction, or survival", and are generally based on dose-response studies conducted under controlled laboratory conditions (EPA 2009e). TRVs must be selected with care since whole classes of organisms (e.g., benthic invertebrates, fishes, mammals), species, populations, and individuals can exhibit varying sensitivities or tolerances for environmental contaminants. If TRVs are selected such that they represent the tolerances of a relatively more sensitive receptor among the full range of potential receptors, then comparisons with these TRVs should provide a reliable, conservative means for assessing the risk of adverse effects to the group of potential receptors as a whole (EPA 2009e). However, the derivation of TRVs is an emerging science and there is not, as yet, a universally accepted set of TRVs; the FWS has not endorsed a particular set of TRVs for the assessment of potential adverse effects to the Act-listed species or critical habitat.

Hazard Quotients (HQs) provide a numerical comparison of exposure concentrations and TRVs. If an HQ is greater than 1.0, then the exposure concentration exceeds the TRV selected for comparison, and exposed receptors may be at some risk of adverse effects. Higher HQs indicate an increased probability of effect to sensitive species, and "as the HQ for [a group of receptors] becomes larger, it is expected that more and more [receptors] in the group would be at risk" (EPA 2009e).

Table 5 summarizes findings from Herrera (2007). It presents predicted equilibrium metal, PAH, and PCB water column concentrations that might occur temporarily as a result of in-water work, and allows for comparisons with contaminant-specific TRVs. Table 5 also presents associated HQs for Aroclor PCBs, Total PCBs, carcinogenic PAHs, and metals. These findings suggest that water column concentrations for several of the PAHs, including anthracene, benzo(b,k) fluoranthene, fluoranthene, fluorene, phenanthrene, and pyrene, may exceed TRVs and present a risk of adverse acute exposures and effects. The same can be said, with less certainty (and perhaps with less severity of effect), for temporarily elevated PCB water column concentrations (Aroclors 1254 and 1260).

Metals, PAHs, and PCBs, as groupings of related contaminants, present a risk of additive or synergistic effects. The various PAHs cause effects in exposed receptors by similar or the same modes of toxic action, as do the various PCBs. As a means to address this potential for toxic interaction, the BA submitted by the FHWA (KCDOT 2008) also presents Hazard Indices which sum individual HQs for the various metals, PAHs, and PCBs (Table 6). These findings lend additional support for the conclusion that PAHs, and to a lesser extent PCBs, are likely to reach temporary concentrations in the water column sufficient to cause adverse effects in acutely exposed fish.

It should be noted that a considerable measure of precaution, or conservatism, is "built-into" these predicted water column concentrations and the interpretation of their significance. Not least of all, many of the TRVs have been developed through laboratory dose-response studies employing long exposure durations (e.g., 24-hour/day, 4- to 7-day test periods). It is unlikely that individual fish would be exposed for these or similar durations as a result of the proposed action. The BA submitted by the FHWA (KCDOT 2008) presents PAH HQs adjusted for shorter-duration exposures. Table 7 presents these adjusted HQs for select PAH parameters, and adjusted Hazard Indices for the PAHs as contaminants with a common mode of action.

Table 5. Predicted water column concentrations, with comparison to TRVs (KCDOT 2008).

| Parameter | Water column Concentration (µg/L) | Toxicity Reference Value (µg/L) | Hazard Quotient |
|---|---|---|---|
| **Metals** | | | |
| Arsenic | 0.8 | 69 | 0.01 |
| Cadmium | 0.02 | 0.36 | 0.06 |
| Copper | 1.31 | 2.3 | 0.57 |
| Lead | 0.2 | 13.9 | 0.01 |
| Mercury | 0.0007 | 1.8 | 0.00 |
| Nickel | 0.53 | 74 | 0.01 |
| Selenium | 0.28 | 290 | 0.00 |
| Silver | 0.01 | 1.9 | 0.01 |
| Tributyltin as Ion | 0.046 | 0.37 | 0.12 |
| Vanadium | 9.6 | 310 | 0.03 |
| Zinc | 1.15 | 23.9 | 0.05 |
| **PAHs** | | | |
| Acenaphthene | 26 | 30 | 0.87 |
| Anthracene | 7.74 | 1.27 | **6.09** |
| Benzo(a)anthracene | 2.02 | 5 | 0.40 |
| Benzo(a)pyrene | 0.57 | 25 | 0.02 |
| Benzo(b)fluoranthene | 0.88 | 0.4 | **2.20** |
| Benzo(g,h,i)perylene | 0.002 | 0.24 | 0.01 |
| Benzo(k)fluoranthene | 0.7 | 0.4 | **1.75** |
| Chrysene | 2.77 | 25 | 0.11 |
| Dibenzo(a,h)anthracene | 0.085 | 0.2 | 0.43 |
| Fluoranthene | 30.96 | 0.9 | **34.40** |
| Fluorene | 17.67 | 0.82 | **21.55** |
| Indeno(1,2,3-cd)pyrene | 0.096 | 0.24 | 0.40 |
| Phenanthrene | 31.63 | 7.7 | **4.11** |
| Pyrene | 21.6 | 0.84 | **25.71** |
| **PCBs** | | | |
| Aroclor-1248 | 1.5 | 10 | 0.15 |
| Aroclor-1254 | 13.48 | 10 | **1.35** |
| Aroclor-1260 | 15.78 | 10 | **1.58** |
| Total PCBs | 0.104 | 10 | 0.01 |

[Note: HQs exceeding 1.0 appear in bold and indicate exposure concentrations in excess of the TRV.]

Table 6. Hazard Indices for contaminants desorbing to the water column.

| Contaminant Group | Hazard Index |
|---|---|
| Metals | 0.87 |
| PAHs | 98.1 |
| Aroclor PCBs | 3.08 |

Source: KCDOT 2008

Table 7. PAH Hazard Quotients adjusted for exposure duration.

| | HQ @ **96** Hour Exposure | HQ @ **12** Hour Exposure | HQ @ **6** Hour Exposure | HQ @ **3** Hour Exposure |
|---|---|---|---|---|
| Anthracene | 6.09 | 1.50 | 0.80 | 0.42 |
| Fluoranthene | 34.40 | 5.88 | 3.08 | 1.58 |
| Fluorene | 21.55 | 6.68 | 3.65 | 1.91 |
| Phenanthrene | 4.11 | 1.51 | 0.84 | 0.45 |
| Pyrene | 25.71 | 6.46 | 3.47 | 1.80 |
| **Hazard Index** (or "Total") | 98.05 | 22.64 | 12.16 | 6.31 |

Source: KCDOT 2008

When adjusted for more realistic or relevant exposure durations (e.g., 3 or 6 hour exposures), the PAH HQs are substantially lower. However, even after adjusting for these somewhat shorter and more realistic exposure durations, Hazard Indices derived for the PAHs (as a class of contaminants exhibiting a common mode of action) are still six to twelve times greater than would be associated with little or no risk of adverse effects (i.e., HQ less than or equal to 1.0).

Taken as whole, these findings (i.e., predicted water column concentrations, HQs, Hazard Indices, and duration-adjusted Hazard Indices) would lead us to conclude that acute contaminant exposures resulting from the proposed action will cause measurable adverse effects to bull trout with a high degree of certainty.

It is difficult to determine with available information whether exposed bull trout may suffer lethal or sub-lethal effects as a result of these acute contaminant exposures. However, Hazard Indices adjusted for shorter and more realistic exposure durations are relatively low. Accordingly, we expect that most bull trout that are acutely exposed to temporarily elevated metal, PAH, and PCB water column concentrations resulting from the action will not suffer lethal effects (i.e., immediate or delayed mortality), but will instead experience less severe sub-lethal effects. These sub-lethal effects may include an incremental reduction in growth or long-term reproductive fitness.

The FWS expects that the contaminant plume resulting temporarily from the proposed action will not span the entire channel at any one time, and will occupy only a small portion of the action area. We expect that acute contaminant exposures with the potential to cause measurable adverse effects to bull trout will be confined to the same area where suspended sediment concentrations are temporarily elevated over ambient, background conditions (i.e., to a distance of approximately 300 ft upstream and downstream of construction activities, depending upon direction of tidal flux). The FWS expects that low numbers of foraging and migrating adult and subadult bull trout will be in the action area at the time of construction and may be temporarily exposed to sediments and water contaminated with metal, PAH, and PCB concentrations sufficient to cause measurable adverse effects.

Acute exposures will be limited in duration, but some of the anticipated effects (e.g., reduced growth or reproductive fitness) will last for the lives of the exposed individuals. Both the PAHs and PCBs are highly toxic, carcinogenic, and fat soluble (lipophilic). The total "body burden", which has significance for the severity of long-term effects, may accumulate over the lives of individuals as a result of multiple, repeated exposures (and/or through multiple exposure pathways). Bull trout that are acutely exposed to contaminants as a result of the proposed action will likely have experienced similar exposures elsewhere (and at other times) within the lower Duwamish River and/or marine waters of the Puget Sound. PAH and PCB contamination are pervasive problems throughout the Puget Sound (Hart Crowser Inc. *et al.* 2007), and low- or moderate-level exposures most likely contribute to total body burdens by way of multiple exposure pathways (including the prey base). Available information does not allow us to predict how exposures within the action area might add incrementally to the accumulative effect of multiple exposures over the lives of individual fish. However, over the long-term, we expect that acute exposures resulting from the proposed action are likely to result in an incremental reduction in individual growth and/or reproductive fitness.

*Chronic Contaminant Exposures and Effects*

The proposed action includes in-water work conducted within contaminated portions of the lower Duwamish River. Construction activities present a risk of directly mobilizing and transporting bottom sediments contaminated with toxic metals, PAHs, and PCBs. The proposed action will also permanently alter hydraulics and channel bed dynamics in the vicinity of the new and existing bascule piers, and may indirectly cause or contribute to post-construction channel bed scour and mobilization of additional contaminated bottom sediment later in time.

The FWS expects that the proposed action will mobilize and transport metal, PAH, and PCB contamination to portions of the lower Duwamish River and Elliot Bay downstream of the project area. Furthermore, we expect that movement of contamination downstream of the project area will, in the short-term, measurably alter patterns of contaminant exposure along some portions of the lower Duwamish River.

Bottom sediments in the vicinity of the proposed bridge replacement contain a complex and variable mixture of metal, PAH, and PCB contamination. A number of these contaminants are present at sediment concentrations that exceed marine and freshwater quality standards and guidelines recommended for the protection of aquatic life. Much of the bottom sediment in the vicinity of the bridge replacement is composed of fine-grained silts and clays. The smallest of these sediments have very slow settling velocities, and in a system as large as the lower Duwamish River may travel long distances before resettling. The best available information leads us to conclude that some of the sediments re-suspended and mobilized by the proposed in-water work may travel the entire length of the lower Duwamish River and into Elliot Bay (a distance of approximately 5 miles downstream) before resettling (Figure 4) (KCDOT 2009).

In addition to sediments that in-water work would directly mobilize and transport downstream, the action may also indirectly cause or contribute to post-construction channel bed scour in the vicinity of the new and existing bascule piers. These piers are large in-water structures, occupying between 6,000 and 7,000 $ft^2$ below MHHW, and exert a strong localized influence on hydraulics and channel bed dynamics. The new bascule piers will be located downstream and closer to the shoreline than the existing bascule piers and foundations. Observations made in the field would suggest there are large deposits of bottom sediment, some immediately downstream of the existing piers that might be easily scoured and transported downstream of the project area as the channel bed adjusts to altered hydraulic conditions. The BA submitted by the FHWA (KCDOT 2008) states that local scour could reach depths of 14 to 22 ft below the existing channel bed grade at some locations.

Sediments that are transported downstream of the project area will carry unknown amounts of metal, PAH, and PCB contamination. Sediment contaminant concentrations vary substantially throughout the South Park reach, including as a function of depth below the channel bed. Fortunately, available information (Figure 6) suggests that some of the highest levels of contamination are a significant distance from the proposed in-water work and new and existing bascule piers. Total PCB concentrations in the immediate vicinity of the existing bridge are low compared to other locations within the reach (KCDOT pers. comm. 2008). Nevertheless, the FWS does expect that the proposed in-water work and subsequent post-construction channel bed scour will transport metal, PAH, and PCB contamination to portions of the lower Duwamish River and Elliot Bay located downstream of the project area.

It is difficult to reliably determine what quantities of contamination may fall out of suspension and re-deposit along downstream portions of the lower Duwamish River and Elliot Bay. Accordingly, it is also difficult to ascertain how this contamination may incrementally affect bull trout, their habitat, and prey base within the action area. The Boeing Plant 2 / Jorgensen Forge EAA, which includes a portion of the South Park reach, is clearly more contaminated than other large portions of the lower Duwamish Waterway; 90 percent or more of the lower Duwamish Waterway (by area) may be less contaminated than the South Park reach (LDWG 2007, pp. 534-537). However, there are also numerous sources of these same contaminants along the lowermost six miles of the Duwamish River, including additional EAAs located both upstream (Norfolk CSO) and downstream (Duwamish / Diagonal, Slip 4) (LDWG 2009b).

The KCDOT, WSDOT-H&LP, and FHWA report that the project planning and design team has discussed the proposed action with numerous parties, including the WDOE, Washington State Department of Natural Resources, EPA, Corps, Boeing, and other participants in the LDWG (e.g., King County Department of Natural Resources and Parks) (KCDOT 2009). These parties are helping to identify and resolve issues for design and construction, and to date have not expressed objection to or identified any fatal-flaws for the project (Sussex pers. comm. 2009). Members of the LDWG have not expressed concern that the proposed action would have unacceptable consequences for planned corrective actions and clean-ups along the lower Duwamish Waterway.

The FWS expects that the quantity of sediment mobilized and transported downstream as a direct effect of the proposed in-water work is likely to be small in comparison to the quantities mobilized later in time as an indirect effect of post-construction channel bed scour. We estimate that the quantity of sediment mobilized by post-construction channel bed scour would fall within the range of 1,400 to 4,000 cubic yards. In effect, while the South Park reach may in general be characterized as depositional, and contaminated sediment has and is now being buried by relatively less contaminated sediment from upstream (LDWG 2007, pp. 267-268), the proposed action will have the indirect effect of temporarily reversing typical patterns of sediment transport. We expect that the fine-grained channel bed will adjust to altered hydraulic conditions quickly, over a matter of days and weeks, and that typical patterns of sediment transport in the vicinity of the new and existing bascule piers will then resume. The proposed action will not cause a permanent change to sediment transport dynamics in the South Park reach.

Even though levels of contamination in the immediate vicinity of the existing bridge appear to be low compared to other locations within the reach, the FWS does expect that re-suspension and subsequent downstream resettling of 1,400 to 4,000 cubic yards of sediment will, in the short-term, measurably alter patterns of contaminant exposure along some portions of the lower Duwamish River. The LDWG has documented effects to the lower Duwamish invertebrate community that may be attributable to similar short-term releases of contaminated sediment (LDWG 2007, p. 535). The LDWG has been sampling and analyzing tissue chemical concentrations in fish and invertebrates from throughout the lower Duwamish River since 1995. During 2004, several months after a series of dredging operations, the LDWG found that tissue Total PCB concentrations were "much higher in some species … than in older (1995 to 1998) and more recent (2005 and 2006) samples" (LDWG 2007, p. 535). This, they suggest, indicates "that exposure to Total PCBs may have been higher immediately following the dredging events than is typical for the lower Duwamish Waterway". They also report that increases in tissue chemical concentrations have been documented elsewhere in the country following dredging operations. Some studies have found that short-term contaminant releases can be as much as three orders of magnitude greater than baseline, pre-dredging releases (Bridges *et al.* 2008, p. 19).

Where contaminated sediments are concerned, it is widely accepted that "exposure processes are dominated by what happens in the top several centimeters of sediment" (Bridges *et al.* 2008, p. 39). The proposed action will transport to downstream locations a volume of sediment and contamination that might otherwise have presented little risk of direct exposure or effects to bull trout, their habitat, and prey base. While suspended in the water column, and after resettling or re-depositing along downstream portions of the lower Duwamish River and Elliot Bay, this sediment-bound contamination will become more bioavailable (and therefore more biologically relevant) for at least a period of time. It is possible that some of this sediment-bound contamination may re-deposit in areas where the surface sediment layer is less contaminated, or not contaminated at all. This altered pattern of exposure will affect the benthic invertebrate community most directly.

We expect that the proposed action will have a measurable, short-term adverse effect on bull trout habitat and the bull trout prey base, perhaps most evident as a temporary increase in benthic invertebrate tissue contaminant concentrations. This short-term adverse effect may also temporarily impair the health and/or reduce the productivity of the bull trout food base in ways that are difficult or impossible to detect. While it is unlikely that the action will cause a shift in aquatic community composition and structure or a fundamental change to primary production or nutrient and organic cycling and dynamics, it is plausible that the incremental effects of the action may include a temporary reduction in prey availability.

In the long-term, we expect that the pattern and severity of chronic contaminant exposures and effects to bull trout, their habitat, and prey base will not be measurably altered. We expect that over a period of months and years the widely and thinly dispersed layer of resettled sediment and sediment-bound contamination will become buried by upstream sources. Furthermore, considerations of scale would lead us to conclude that prevailing patterns of sediment transport, contaminant release, mobility, and exposure will, over time, render the incremental effects of the action immeasurable. While not insignificant, the contaminant exposures and effects resulting incrementally from the proposed action will operate on scales that are small in comparison to the baseline level and extent of contamination throughout the action area. We expect that the proposed action will not cause measurable permanent changes to the pattern or severity of chronic contaminant exposures within the action area. No measurable, incremental long-term or permanent effects to bull trout, their habitat, or prey base are expected.

The proposed action will temporarily alter patterns of contaminant exposure and will result in measurable, short-term adverse effects to bull trout habitat and the bull trout prey base. We expect that low numbers of foraging and migrating adult and subadult bull trout use the action area and may experience diminished sources of prey or other temporary conditions (impaired habitat suitability and function on a localized scale) which significantly disrupt their normal behaviors (i.e., ability to successfully feed, move, and/or shelter). Available information does not allow us to predict how contaminant exposures within the action area will or might add incrementally to the accumulative effect of multiple exposures over the lives of individual fish. However, we do expect that the variety of exposures described here will, over the long-term, contribute to an incremental reduction in individual growth and/or reproductive fitness.

Summary of Effects (Matrix of Pathways and Indicators)

An earlier section applied the *Matrix of Diagnostics / Pathways and Indicators* (USFWS 1998) as a tool for describing whether habitat is functioning adequately, functioning at risk, or functioning at unacceptable levels of risk at the scale of the action area (see Environmental Baseline in the Action Area). Table 8 summarizes the effects of the action using this same matrix. For a fuller description of the anticipated effects of the action see the preceding sub-sections.

Table 8. Effects of the action ("Matrix of Pathways & Indicators").

| Pathway | Indicator | Baseline Conditions | Effect of the Action |
|---|---|---|---|
| Water Quality | Temperature | Unacceptable Risk | Maintain |
| | Sediment | Unacceptable Risk | **Degrade** (Temporary) |
| | Chemical Contamination & Nutrients | Unacceptable Risk | **Degrade** (Temporary) |
| Habitat Access | Physical Barriers | At Risk | **Degrade** (Temporary) |
| Habitat Elements | Substrate | Unacceptable Risk | **Degrade** (Temporary) |
| | Large Woody Debris | Unacceptable Risk | Maintain |
| | Pool Frequency / Quality | Unacceptable Risk | Maintain |
| | Large Pools | Unacceptable Risk | Maintain |
| | Off-Channel Habitat | Unacceptable Risk | Maintain |
| | Refugia | Unacceptable Risk | Maintain |
| Channel Conditions & Dynamics | Width/Depth Ratio | Functioning Adequately | Maintain |
| | Streambank Condition | Unacceptable Risk | Maintain |
| | Floodplain Connectivity | Unacceptable Risk | Maintain |
| Flow / Hydrology | Peak / Base Flows | Unacceptable Risk | Maintain |
| | Drainage Network | At Risk | Maintain |
| Watershed Conditions | Road Density / Location | At Risk | Maintain |
| | Disturbance History | Unacceptable Risk | Maintain |
| | Riparian Reserve | Unacceptable Risk | Maintain |

Effects to the PCEs of Designated Bull Trout Critical Habitat

An earlier section identified the PCEs that define bull trout critical habitat and described their baseline condition in the action area (Environmental Baseline, Status of Critical Habitat in the Action Area). The following section discusses the effects of the action with reference to seven of the eight PCEs. Designated critical habitat present within the action area does not include PCE #3 (*Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival*).

The proposed action will have only temporary adverse effects to designated bull trout critical habitat. The net permanent change (increase) in fill volume and area below MHHW is negligible, the proposed stormwater design will have no measurable long-term effects to surface water quality or hydrology, and the action will not cause measurable permanent changes to the pattern or severity of chronic contaminant exposures within the action area.

With removal of the existing bascule piers, intermediate piers, and foundations, permanent structures will increase the area of fill below MHHW by approximately 270 $ft^2$ (KCDOT 2009). The project will permanently remove approximately 350 creosote-treated wood piles associated with the existing bridge pier protection system, and will use steel piles instead when constructing the new bridge pier protection system. The project will also create or enhance approximately 6,000 $ft^2$ of tidally-influenced emergent marsh, and restore approximately 2,300 $ft^2$ of shrub-dominated transition zone in the vicinity of the new and existing bridges (KCDOT 2009).

The proposed action will have unavoidable temporary adverse effects to designated bull trout critical habitat. Some of these adverse effects result directly from construction activities conducted within the lower Duwamish River, including the use of large temporary in-water and over-water structures (i.e., work trestles, floating platforms, and a sand blanket), and temporary increases in in-water SPLs and turbidity. However, additional adverse effects to designated bull trout critical habitat will or may result indirectly from post-construction channel bed scour in the vicinity of the new and existing bridge piers, from temporarily altered patterns of contaminant exposure downstream of the project area, and resulting diminished sources of prey and habitat function on a localized scale.

PCE #1 (*Water Temperatures*) – The waters within the action area are functioning at unacceptable levels of risk for the temperature indicator. The lower Duwamish River frequently exhibits elevated surface water temperatures during summer months. Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of most years. The proposed project will restore and enhance left-bank shallow water, shoreline, and riparian zones in the immediate vicinity of the new bridge. The proposed stormwater design will not cause or contribute to measurable increases in surface water temperature or degrade thermal refugia within the action area. As such, effects to PCE #1 are considered insignificant.

PCE #2 (*Complex Stream Channels*) – The lower Duwamish River exhibits greatly reduced instream habitat complexity and diversity. The action area exhibits fragmented and heavily degraded riparian conditions, extensive bank hardening and channelization, a fairly uniform U-shaped channel, degraded substrate conditions, greatly diminished pool, refuge, and off-channel habitat, and a great many and wide variety of artificial overwater structures and encumberances. Instream habitat function is substantially diminished compared to historic conditions.

The long-term effects of the proposed action will not cause or contribute to a further simplification of these instream habitats; no permanent adverse effects to PCE #2 will result from the project. However, temporary effects below MHHW will reduce instream habitat function for approximately 26 months (August 2010 through October 2012).

These adverse effects result directly from construction activities conducted within the lower Duwamish River, including the use of large temporary in-water and over-water structures. These structures will occupy or cover more than 20,000 $ft^2$ below MHHW. The proposed action will have significant temporary adverse effects to PCE #2, limited in both physical extent and duration.

PCE #4 (*Natural Hydrograph*) – The hydrology of the lower Duwamish River has been substantially altered from historic conditions. The project will influence patterns of runoff and infiltration on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph within the project's receiving waters. As such, effects to PCE #4 are considered insignificant.

PCE #5 (*Sources of Cold Water*) – The project will influence patterns of runoff and infiltration on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph. The proposed stormwater design will not cause or contribute to measurable increases in surface water temperature or degrade thermal refugia within the action area. As such, effects to PCE #5 are considered insignificant.

PCE #6 (*Migratory Corridors With Minimal Impediments*) – The lower Duwamish River's function as a migratory corridor is greatly diminished. Elevated surface water temperatures, sediment and surface water contamination, extensive bank hardening and channelization, loss of pool, refuge, and off-channel habitat, and a wide variety of artificial overwater structures present physical, biological, and water quality impediments to free movement.

The proposed action will not create or contribute to any permanent physical, biological, or water quality impediments to migration; no permanent adverse effects to PCE #6 will result from the project. However, the project's effects, including temporary in-water and over-water structures occupying more than 20,000 $ft^2$ below MHHW, will present a temporary, partial barrier to bull trout movements for approximately 26 months (August 2010 through October 2012). In addition, construction activities will also have measurable temporary adverse effects on the function of the migratory corridor. Elevated SPLs resulting from impact driving and proofing of steel pilings will impair function of the migratory corridor intermittently, over approximately 100 working days between August 1, 2009 and October 31, 2012. Construction activities will also temporarily degrade surface water quality (to approximately 300 ft upstream and downstream) for as many as 485 working days. The proposed action will have significant temporary adverse effects to PCE #6, limited in both physical extent and duration.

PCE #7 (*Food Base*) – Despite heavily degraded flooplain, riparian, and instream habitat conditions, the lower Duwamish River still supports salmon and steelhead, as well as other native and non-native fishes. This represents a sizable prey base for adult and subadult bull trout. However, sediments and surface water are contaminated throughout large portions of the lower Duwamish River and these present an ongoing threat to the health of the benthic invertebrate community and food web in general.

The proposed action will not, in the long-term, measurably diminish the productivity or availability of bull trout prey; no permanent adverse effects to PCE #7 will result from the project. However, the proposed action will have significant temporary adverse effects to PCE #7, limited in both physical extent and duration. Placement of a large sand blanket will have important, short-term benefits for bull trout (i.e., reduced contaminant exposure during construction), but may also have temporary adverse effects on designated bull trout critical habitat. The sand blanket will cover an area below MHHW as large as 35,000 $ft^2$ (0.8 acre). This material will differ in character from the native substrates and will remain in-place until removed as part of a future clean-up or remedial action conducted within the South Park reach. The benthic community inhabiting these native substrates will be adversely affected and may not recover for months or years. We expect that placement of a large sand blanket will have measurable short-term adverse effects on bull trout habitat and the bull trout prey base, including a temporary reduction in prey availability.

The proposed action will not cause permanent changes to the pattern or severity of chronic contaminant exposures within the action area, but may, in the short-term, alter contaminant exposures along some portions of the lower Duwamish River. We expect these altered patterns of exposure will have measurable, short-term adverse effects on bull trout habitat and the bull trout prey base, including a temporary reduction in prey availability.

PCE #8 (*Water Quantity and Quality*) – Water quantity and quality conditions are degraded throughout the action area. Extremes of temperature may prevent or discourage bull trout from using and occupying habitats along the lower Duwamish River from July through September of most years, and sediment and surface water contamination present an ongoing threat to the health of the benthic invertebrate community and food web in general. These baseline conditions limit normal bull trout reproduction, growth, and survival.

The proposed action will have no measurable, permanent adverse effects to water quantity or quality; no permanent adverse effects to PCE #8 will result from the project. The proposed action will not cause permanent changes to the pattern or severity of chronic contaminant exposures within the action area. The proposed stormwater design is expected to achieve measurable reductions in post-project annual stormwater loadings of TSS, total Cu, and total and dissolved Zn, and will also measurably reduce post-project treated effluent/discharge concentrations for each pollutant (KCDOT 2009). The project will influence patterns of runoff and infiltration on a local scale, but will have no discernible effect on the size or frequency of peak, high, low or base flows, or on day-to-day or seasonal fluctuations of the natural hydrograph. The project will not cause or contribute to measurable increases in surface water temperature or degrade thermal refugia within the action area.

We expect that the proposed action will have temporary adverse effects to PCE #8, limited in both physical extent and duration. Construction activities will temporarily degrade surface water quality (to approximately 300 ft upstream and downstream) for as many as 485 working days. The proposed action may also, in the short-term, measurably alter contaminant exposures along some portions of the lower Duwamish River. We expect these altered patterns of exposure will have measurable, short-term adverse effects on bull trout habitat, including impaired habitat suitability and function on a localized scale. The proposed action will have significant temporary adverse effects to PCE #8, limited in both physical extent and duration.

Indirect Effects

Indirect effects are caused by or result from the proposed action, are later in time, and are reasonably certain to occur. Indirect effects may occur outside of the area directly affected by the action (USFWS and NMFS 1998).

The proposed project will construct a new South Park Bridge over the lower Duwamish River and demolish the existing, structurally deficient bridge at the same approximate location. The project will not increase traffic capacity within the project limits, and no new development is contingent or dependent upon the project's completion. The FWS expects no discernible changes in the rate or pattern of land use conversion will result, in whole or in part, from construction of the project.

The FWS expects the proposed project will alter hydraulics and channel bed dynamics in the vicinity of the new and existing bridge piers, and may thereby indirectly cause or contribute to post-construction channel bed scour and mobilization of contaminated bottom sediment later in time. We expect the project will, in the short-term, measurably alter patterns of contaminant exposure along some portions of the lower Duwamish River, with potential to cause indirect adverse effects to bull trout habitat and the bull trout prey base. In the long-term, the FWS expects that the pattern and severity of chronic contaminant exposures and effects to bull trout, their habitat, and prey base will not be measurably altered.

Effects of Interrelated & Interdependent Actions

Interrelated actions are defined as actions "that are part of a larger action and depend on the larger action for their justification"; interdependent actions are defined as actions "that have no independent utility apart from the action under consideration" (50 CFR section 402.02). Off-site disposal of characteristically hazardous or toxic waste (or wastewater) is the only identifiable interrelated or interdependent action. The proposed project will dispose of these materials according to all applicable State and federal requirements, at an approved upland disposal site or in-water dredged material disposal site operating under DMMP (KCDOT 2009, WDNR 2009). Sites operating under the DMMP were addressed with an earlier consultation (1-3-05-I-0298/IC-

0299). Those sites, and any effects associated with their management, are not a focus of this Opinion.

## CUMULATIVE EFFECTS (Bull Trout and Designated Critical Habitat)

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Future actions with particular relevance for the action area include planned clean-up and remedial actions to address toxic soil, surface/groundwater, and sediment contamination throughout the lower Duwamish River and floodplain. Several large and heavily-contaminated sites, among them the Boeing Plant 2 / Jorgensen Forge EAA, have not yet benefited from planned, comprehensive clean-up actions. The LDWG, EPA, and WDOE expect that these actions will be on-going for many years into the future. Some may be federally-funded or permitted and will require consultation, but others may not.

This Opinion has described a variety of contaminant exposures and resulting effects to bull trout, their habitat, and prey base (see Effects of the Action, Acute Exposure to Hazardous Contaminants, Chronic Contaminant Exposures and Effects). However, the exposures and effects described here are not unique to this action. It is reasonable to expect that future clean-up and remedial actions conducted along the lower Duwamish River will present the risk of similar short-term exposures and adverse effects to bull trout and designated bull trout critical habitat. However, we expect that the cumulative effect of these actions over time will be largely or exclusively beneficial.

Future actions to clean-up the lower Duwamish River's surface waters and sediment will improve the quality and function of FMO habitat in the action area. At the scale of the action area, we expect these actions will address an important limiting factor on normal bull trout reproduction, growth, and survival. These actions will improve long-term conditions for bull trout and their prey, will address to some degree existing impediments to free movement and function of the migratory corridor, and will allow one or more PCEs of designated bull trout critical habitat to become more completely established and functional within the action area.

The lower Duwamish River floodplain is today very heavily developed. It is unlikely that future development within the action area will further degrade floodplain, riparian, or instream conditions. Instead, we expect that redevelopment according to current environmental standards may over time make modest improvements to these conditions. The LDWG and other interested parties have plans that include riparian and instream enhancements. As part of the larger effort to clean-up the lower Duwamish River, such actions will help to more completely restore proper ecosystem function.

Taken as a whole, the foreseeable future State, tribal, local, and private actions will have both beneficial effects and adverse effects to bull trout and designated bull trout critical habitat. However, the FWS expects that the cumulative effect of these actions over time will be largely beneficial. At the scale of the action area, we expect future actions will improve the quality and function of FMO habitat and address important limiting factors on normal bull trout reproduction, growth, and survival.

## CONCLUSION

The FWS has reviewed the current status of bull trout in its coterminous range, the current status of designated critical habitat within the Puget Sound (Unit 28) and coterminous range, the environmental baseline for the action area, the direct and indirect effects of the proposed project, the effects of interrelated and interdependent actions, and the cumulative effects that are reasonably certain to occur in the action area.

It is the FWS's Opinion that the action, as proposed, is not likely to jeopardize the continued existence of the bull trout in its coterminous range. This determination is based on the following:

- The action area contains FMO habitat for bull trout. The waters within the action area play an important role as a migratory corridor linking the Duwamish River, Green River, and their tributaries to nearshore marine waters of the Puget Sound, and as a source of prey for anadromous bull trout of the Puget Sound Management Unit. FMO habitat is important for maintaining a diversity of life history forms and for providing access to productive foraging areas (USFWS 2004).
- Anadromous adult and subadult bull trout are known to occur in the action area and may occupy these waters at any time of year. Current information suggests that these bull trout most likely originate from the local populations of the Puyallup River, Snohomish-Skykomish River, and Skagit River core areas. The Green and Duwamish Rivers do not support local bull trout populations, spawning, or rearing (USFWS 2004), and suitable bull trout spawning and rearing habitats are not present in the action area.
- The proposed action will adversely affect low numbers of foraging and migrating adult and subadult bull trout. Temporary adverse effects include exposure to elevated underwater SPLs resulting from pile driving and proofing, to elevated levels of turbidity, re-suspended sediments contaminated (or potentially contaminated) with metals, PAHs, and PCBs, and to elevated water column concentrations of these same contaminants. The proposed action will have temporary adverse effects on the condition and function of the migratory corridor and bull trout prey base (i.e., a measurable temporary reduction in prey availability).
- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to habitat and avoid and minimize impacts during construction. The action's temporary adverse effects are limited in both physical extent and duration. The proposed action will have no permanent adverse effects to bull trout, their habitat, or prey base. The direct and indirect effects of the proposed action

(permanent and temporary) will not preclude bull trout from foraging, migrating, or overwintering within the action area.

- With full implementation of the proposed conservation measures, we expect low numbers of adult and subadult bull trout will be adversely affected by construction activities. Exposure to construction activities may kill or injure a limited number of bull trout and will significantly disrupt normal bull trout behaviors (feeding, moving, and sheltering). Individual bull trout may experience reduced growth or reproductive fitness (fecundity) as a result of adverse sub-lethal exposures and effects. However, because only low numbers of adult and subadult bull trout will be adversely affected, and these bull trout originate from the local populations within three or more core areas, we conclude that the action's temporary adverse effects will not measurably reduce numbers (abundance), reproduction (productivity), or the likelihood of persistence at the scale of the local populations or core areas (Puyallup River, Snohomish-Skykomish River, and Skagit River).
- With full implementation of the proposed conservation measures, the action's temporary adverse effects to bull trout habitat (i.e., condition and function of the migratory corridor and bull trout prey base) will not measurably affect bull trout reproduction, numbers, or distribution. Because the best available information suggests only low numbers of foraging and migrating bull trout use the action area (and on an infrequent basis), we conclude that relatively few bull trout will experience these temporary adverse effects to habitat. The proposed action will have no measurable long-term effects to surface water quality or hydrology, and will not cause measurable permanent changes to the pattern or severity of chronic contaminant exposures within the action area. The proposed action will provide long-term benefits associated with the removal of creosote-treated wood pilings, on-site habitat restoration and enhancement, and improved stormwater controls.
- The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not appreciably reduce the likelihood of survival and recovery of the species. The anticipated direct and indirect effects of the action (permanent and temporary) will not measurably reduce bull trout reproduction, numbers, or distribution at the scale of the core areas or Puget Sound interim recovery unit. The anticipated direct and indirect effects of the action will not alter the status of bull trout at the scale of the Puget Sound interim recovery unit or coterminous range.

It is the FWS's Opinion that the action, as proposed, will not destroy or adversely modify designated bull trout critical habitat. This determination is based on the following:

- The lower Duwamish River and nearshore marine waters of Elliot Bay are designated as critical habitat for bull trout (Unit 28 – Puget Sound). The waters within the action area, including tidally-influenced wetlands below MHHW, contain seven of the eight PCEs that define bull trout critical habitat. These waters play an important role as a migratory corridor linking the Duwamish River, Green River, and their tributaries to nearshore marine waters of the Puget Sound, and as a source of prey for anadromous bull trout of the Puget Sound Management Unit.

- The proposed action will have temporary adverse effects to designated bull trout critical habitat. No measurable, permanent adverse effects to designated bull trout critical habitat are expected. The net permanent change (i.e., increase) in fill volume and area below MHHW is negligible, the proposed stormwater design will have no measurable long-term effects to surface water quality or hydrology, and the action will not cause measurable permanent changes to the pattern or severity of chronic contaminant exposures within the action area.
- The proposed action incorporates both permanent design elements and conservation measures which will reduce effects to designated critical habitat and avoid and minimize impacts during construction. The action's temporary adverse effects to designated bull trout critical habitat are limited in both physical extent and duration.
- Construction activities will reduce instream habitat function and complexity, and will present a temporary, partial barrier to bull trout movements, for approximately 26 months. Construction activities will also temporarily degrade surface water quality (to 300 ft upstream and downstream) for as many as 485 working days. Placement of a 0.8 acre sand blanket, and temporary changes to the pattern of contaminant exposures along downstream portions of the lower Duwamish River, will have measurable, short-term adverse effects on bull trout habitat and the bull trout prey base. However, none of the proposed action's temporary adverse effects to designated bull trout critical habitat are expected to persist for more than a few years.
- The direct and indirect effects of the proposed action (permanent and temporary) will not preclude bull trout from foraging, migrating, or overwintering within the action area. Effects to habitat connectivity will be insignificant at the scale of the core areas (Puyallup River, Snohomish-Skykomish River, and Skagit River) and Puget Sound interim recovery unit.
- Within the action area, designated bull trout critical habitat will retain its current ability to establish functioning PCEs. The anticipated direct and indirect effects of the action, combined with the effects of interrelated and interdependent actions, and the cumulative effects associated with future State, tribal, local, and private actions will not prevent the PCEs of critical habitat from being maintained, and will not degrade the current ability to establish functioning PCEs at the scale of the action area. Critical habitat within the action area will continue to serve the intended conservation role for the species at the scale of the core areas, Puget Sound interim recovery unit, and coterminous range.

## INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is defined by the FWS as an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Harass is defined by the FWS as an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering (50 CFR 17.3). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by the FHWA so that they become binding conditions of any grant or permit issued, as appropriate, for the exemption in section 7(o)(2) to apply. The FHWA has a continuing duty to regulate the activity covered by this incidental take statement. If the FHWA (1) fails to assume and implement the terms and conditions or (2) fails to require the contractor or applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the FHWA must report the progress of the action and its impact on the species to the FWS as specified in the incidental take statement [50 CFR section 402.14(i)(3)].

**AMOUNT OR EXTENT OF TAKE**

The FWS anticipates that take in the form of harm and harassment of anadromous adult and subadult bull trout from the Puyallup River, Snohomish-Skykomish River, and Skagit River core areas is likely to result from the proposed action.

The FWS anticipates that incidental take of individual bull trout will be difficult to detect or quantify for the following reasons: 1) the low likelihood of finding dead or injured adults or subadults; 2) delayed mortality; and, 3) the relationship between habitat conditions and the distribution and abundance of individuals is imprecise such that a specific number of affected individuals cannot be practically obtained. Using post project habitat conditions as a surrogate indicator of take, the FWS anticipates that the following forms of take will occur as a result of activities associated with the project:

1. Incidental take of bull trout in the form of ***harm*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing. Approximately 545 steel piles, including test piles, between August 1, 2009 and October 31, 2012 (approximately 100 working days).
    - All adult and subadult bull trout within the wetted perimeter of the lower Duwamish River to a distance of approximately 1,775 ft upstream and downstream of piling installation operations will be harmed.

2. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact pile driving and proofing.

Approximately 540 steel piles between August 1, 2009 and October 31, 2012 (approximately 100 working days).

- All adult and subadult bull trout within the wetted perimeter of the lower Duwamish River to a distance of approximately 2,350 ft upstream and 6,060 ft downstream of piling installation operations will be harassed.

3. Incidental take of bull trout in the form of ***harassment*** as a direct effect of exposure to elevated underwater SPLs resulting from impact driving of test piles. A limited number of test piles may be driven without the use of a noise attenuation device between August 1, 2009 and October 31, 2012 (approximately 1 working day and 5 steel piles), to collect baseline data and determine performance of the noise attenuation device.

   - All adult and subadult bull trout within the wetted perimeter of the lower Duwamish River to a distance of approximately 2,350 ft upstream and 8,200 ft downstream of piling installation operations will be harassed.

4. Incidental take of bull trout in the form of ***harm*** resulting from degraded surface water quality during construction, exposure to elevated turbidity and sedimentation, and acute contaminant exposures. Water quality will be degraded intermittently during the approximately 485-day period when construction activities are being completed below MHHW of the lower Duwamish River. Take will result when levels of turbidity reach or exceed the following:

   i) 160 NTUs above background at any time; or

   ii) 59 NTUs above background for more than 1 hour, cumulatively, over a 10-hour workday; or

   iii) 22 NTUs above background for more than 7 hours, cumulatively, over a 10-hour workday.

   - All adult and subadult bull trout within the wetted perimeter of the lower Duwamish River, from a point approximately 300 ft upstream to a point approximately 300 ft downstream of construction activities, will be harmed between August 1, 2009 and October 31, 2012.

## EFFECT OF THE TAKE

In the accompanying Opinion, the FWS has determined that the level of anticipated take is not likely to result in jeopardy to the bull trout or destruction or adverse modification of designated bull trout critical habitat.

The proposed action incorporates design elements and conservation measures which the FWS expects will reduce permanent effects to habitat and avoid and minimize impacts during construction. The FWS assumes the KCDOT, WSDOT-H&LP, and FHWA will fully implement these measures and therefore they have not been specifically identified as Reasonable and Prudent Measures or Terms and Conditions.

## REASONABLE AND PRUDENT MEASURES

The FWS believes that the following reasonable and prudent measures (RPMs) are necessary and appropriate to minimize the impact of incidental take to bull trout:

1. Minimize and monitor incidental take caused by elevated underwater SPLs from impact driving and proofing of steel piles.
2. Maximize effectiveness of the noise attenuation device to maintain a passable corridor through the action area during impact driving and proofing of steel piles.
3. Minimize and monitor incidental take caused by elevated turbidity and sedimentation during construction.
4. Minimize and monitor incidental take caused by acute contaminant exposures during construction.

## TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, the FHWA must comply with the following terms and conditions, which implement the RPMs described above. These terms and conditions are non-discretionary.

The following terms and conditions are required for the implementation of RPM 1:

1. The FHWA, WSDOT-H&LP, and KCDOT shall:

   a. Use a noise attenuation device consisting of a bubble curtain (i), temporary noise attenuation pile (ii), or functional equivalent (iii), when impact driving and proofing steel piles.

      i. A bubble curtain utilizing air compressor(s), supply lines to deliver air, distribution manifolds or headers, perforated aeration pipe(s), and a frame; the bubble curtain shall:

         (1) Include a frame which facilitates transport and placement of the system, keeps the aeration pipes stable, and provides ballast to counteract the buoyancy of the aeration pipes in operation.

         (2) Include an aeration pipe system consisting of multiple layers of perforated pipe rings, stacked vertically in accordance with the following:

| Water Depth (m) | No. of Layers |
|---|---|
| less than 5 | 2 |
| 5 to less than 10 | 4 |
| 10 to less than 15 | 7 |
| 15 to less than 20 | 10 |
| 20 to less than 25 | 13 |

(3) Arrange the pipe rings (in all layers) in a geometric pattern such that the pile being driven is completely enclosed by bubbles for the full depth of the water column and with a radial dimension such that the rings are no more than 0.5 meter from the outside surface of the pile.

(4) Ensure that the lowest layer of perforated aeration pipe is in contact with the substrate (without sinking into the substrate) and shall accommodate for sloped conditions.

(5) Size the air holes 1.6 mm (1/16-inch) in diameter and space them approximately 20 mm (3/4 inch) apart. Air holes with this size and spacing shall be placed in four adjacent rows along the pipe to provide uniform bubble flux.

(6) Provide a bubble flux of 3.0 cubic meters per minute per linear meter of pipe in each layer (32.91 cubic feet per minute per linear foot of pipe in each layer). The total volume of air per layer is the product of the bubble flux and the circumference of the ring:

$$V_t = 3.0\ m^3/min/m * \text{Circ of the aeration ring in m}$$

or

$$V_t = 32.91\ ft^3/min/ft * \text{Circ of the aeration ring in ft}$$

(7) Provide meters as follows:

(a) Pressure meters shall be installed at all inlets to aeration pipelines and at points of lowest pressure in each branch of the aeration pipeline.

(b) Flow meters shall be installed in the main line at each compressor and at each branch of the aeration pipelines at each inlet. In applications where the feed line from the compressor is continuous from the compressor to the aeration pipe inlet the flow meter at the compressor can be eliminated.

(c) Flow meters shall be installed according to the manufacturer's recommendation based on either laminar flow or non-laminar flow.

ii. A temporary noise attenuation pile. Design specifications and monitoring reports or other information documenting equivalent function shall be submitted to the FWS for review a minimum of 60 days prior to impact pile driving and proofing.

iii. A functional equivalent to the design described above (2.a.i.). Design specifications and monitoring reports or other information documenting equivalent function shall be submitted to the FWS for review a minimum of 60 days prior to impact pile driving and proofing.

b. Submit a hydroacoustic monitoring plan at least 45 days prior to impact pile driving and proofing. The hydroacoustic monitoring plan shall be prepared by someone with proven expertise in the field of underwater acoustics and data collection and shall include the name and qualifications of the biologist to be present during impact pile driving and proofing.

c. Conduct a performance test of the noise attenuation device, prior to any impact pile driving or proofing. If a bubble curtain is utilized, the performance test shall confirm the calculated pressures and flow rates at each manifold ring.

d. Ensure that a qualified biologist is present during all impact pile driving and proofing operations to observe and report any indications of dead, injured or distressed fish.

e. Document the effectiveness of the noise attenuation device through hydroacoustic monitoring of a minimum of five piles, as early in the project as possible. Factors to consider in identifying the piles to be monitored include, but are not limited to: bathymetry of the project site, total number of piles to be impact driven and proofed, depth of water, and distance from shore. This monitoring shall include SPLs, and single-strike and cumulative SELs, with and without use of the noise attenuation device, monitored at a distance of 10 meters from the pile at mid-water depth.

f. Contact the FWS within 24 hours if hydroacoustic monitoring indicates that SPLs will exceed the extent of take exempted in the Opinion. The FHWA shall consult with the FWS regarding modifications to the proposed action in an effort to reduce the SPLs below the limits of take and continue hydroacoustic monitoring.

g. Submit a monitoring report to the consulting biologist(s) at the FWS (Washington Fish and Wildlife Office; Lacey, Washington) within 60 days of completing hydroacoustic monitoring. The report shall include the following information:

   i. Size and type of piles driven and proofed;

   ii. A detailed description of the noise attenuation device, including the design specifications identified above;

   iii. The impact hammer force used to drive and proof piles;

   iv. A description of the monitoring equipment;

   v. The distance between hydrophone and pile;

   vi. The depth of the hydrophone;

   vii. The distance from the pile to the wetted perimeter;

   viii. The depth of water;

ix. The depth into the substrate the pile was driven and proofed;

x. The physical characteristics of the bottom substrate into which the piles were driven and proofed; and

xi. The results of the hydroacoustic monitoring, including the frequency spectrum, SPLs, and single-strike and cumulative SEL with and without the noise attenuation device. The report must also include the ranges and means for peak, rms, and SELs for each pile.

The following terms and conditions are required for the implementation of RPM 2:

1. The FHWA, WSDOT-H&LP, and KCDOT shall, to the fullest extent practicable and through design, testing, and careful implementation, maximize effectiveness of the noise attenuation device with the goal of achieving a target of 16 dB attenuation measured at a distance of 10 meters from the pile. Based on information included in the BA Addendum, the unattenuated single-strike SEL is expected to be 181 dB. As such, the noise attenuation device will need to achieve 16 dB attenuation (at a distance of 10 meters) in order to prevent an accumulated SEL of 187 dB from extending over more than 75 percent of the wetted channel width. If the attenuation goal is not achieved, work shall be allowed to continue while the action agencies consult with the FWS and identify reasonable alternatives to improve performance.

The following terms and conditions are required for the implementation of RPM 3:

1. The FHWA, WSDOT-H&LP, and KCDOT shall monitor turbidity levels in the lower Duwamish River during sediment-generating activities (and/or when maneuvering barges). The FHWA, WSDOT-H&LP, and KCDOT shall monitor turbidity when conducting work below MHHW, except when this work is fully contained within steel sheet pile cofferdams with no release to adjacent waters.
2. Monitoring shall be conducted at a distance of 150 ft upstream and/or downstream of sediment-generating activities, dependent on position within the tide-cycle.
3. Monitoring shall be conducted at three locations along transects extending perpendicular to flow; to the extent practicable, one sample location shall be positioned along the transect near the mid-point of the wetted channel.
4. Monitoring shall be conducted at 15-minute intervals from the start of sediment-generating activities. If turbidities measured over the course of two consecutive 15-minute sample intervals do not exceed 22 NTUs over background, then monitoring of sediment-generating activities will be conducted for the remainder of the workday at a frequency of once every 3 hours, or if there is a visually appreciable increase in turbidity.
5. If at any time monitoring conducted 150 ft upstream or downstream of sediment-generating activities indicates turbidity in excess of 22 NTUs over background, then monitoring shall instead be conducted at 300 feet upstream and/or downstream of

sediment-generating activities (dependent on position within the tide-cycle). Monitoring shall be conducted at 15-minute intervals until turbidity falls below 22 NTUs over background.

6. If turbidity levels measured at 300 ft upstream or downstream of sediment-generating activities exceed 22 NTUs over background for more than 7 hours cumulatively over any 10-hour workday (or 59 NTUs over background for more than 1 hour), then the amount of take authorized by the Incidental Take Statement will have been exceeded. Sediment-generating activities shall cease, and the FHWA and/or WSDOT-H&LP shall contact the FWS's consulting biologist (Ryan McReynolds; 360-753-6047) at the Washington Fish and Wildlife Office in Lacey, Washington.
7. Monitoring shall be conducted to establish background turbidity levels away from the influence of sediment-generating activities. Background turbidity shall be monitored at least once daily during sediment-generating activities. In the event of a visually appreciable change in background turbidity, an additional sample shall be taken.
8. The FHWA, WSDOT-H&LP, and KCDOT shall submit a monitoring report by March 31 following each in-water construction season, to include at a minimum, the following: (a) dates and times of construction activities, (b) monitoring results, sample times, locations, and measured turbidities (in NTUs), (c) summary of construction activities and measured turbidities associated with those activities (including barge operations), and, (d) summary of corrective actions taken to reduce sediment/turbidity.

The following terms and conditions are required for the implementation of RPM 4:

1. The FHWA, WSDOT-H&LP, and KCDOT shall provide to the FWS a copy of the Engineer-approved SPCC plan prior to any operations generating a contaminated (or potentially contaminated) waste stream (i.e., sediments or water).
2. Protocols for waste sampling and characterization shall strictly adhere to Quality Assurance/ Quality Control standards, so as to ensure contaminated and uncontaminated waste streams (i.e., sediments and water) are accurately characterized, to prevent co-mingling of contaminated and uncontaminated waste streams, and to inform selection of appropriate treatment and disposal methods.
3. The FHWA, WSDOT-H&LP, and KCDOT shall provide and maintain on-site the materials and equipment necessary to ensure at all times there is sufficient capacity for the temporary storage and proper segregation of generated wastes (including water in-contact with contaminated or potentially contaminated sediments).
4. The FHWA, WSDOT-H&LP, and KCDOT shall ensure that all equipment used to handle contaminated waste streams (i.e., sediments and water), including containment and transport BMPs, storage containers, and temporary on-site treatment facilities or BMPs, is properly decontaminated prior to handling any uncontaminated waste stream.

5. The FHWA, WSDOT-H&LP, and KCDOT shall document waste handling, containment, testing, storage, treatment, and disposal operations according to all applicable State and federal requirements, and shall provide to the FWS a copy of this documentation following each in-water construction season. This documentation shall include, at a minimum, the following: (a) A description of the treatment facilities or BMPs utilized on-site; and, (b) A quantitative waste characterization or profile for all sediments disposed at an upland disposal site(s), for all sediments and water disposed at an in-water dredged material disposal site(s), and for all return water discharged on-site.
6. The Engineer-approved SPCC plan and all subsequent documentation shall be submitted to the FWS's consulting biologist (Ryan McReynolds, 360-753-6047) at the Washington Fish and Wildlife Office in Lacey, Washington.

The FWS expects that the amount or extent of incidental take described above will not be exceeded as a result of the proposed action. The RPMs, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The FHWA, WSDOT-H&LP, and KCDOT must provide an explanation of the causes of the taking and review with the FWS the need for possible modification of the reasonable and prudent measures.

The FWS is to be notified within three working days upon locating a dead, injured or sick endangered or threatened species specimen. Initial notification must be made to the nearest U.S. Fish and Wildlife Service Law Enforcement Office. Notification must include the date, time, precise location of the injured animal or carcass, and any other pertinent information. Care should be taken in handling sick or injured specimens to preserve biological materials in the best possible state for later analysis of cause of death, if that occurs. In conjunction with the care of sick or injured endangered or threatened species or preservation of biological materials from a dead animal, the finder has the responsibility to ensure that evidence associated with the specimen is not unnecessarily disturbed. Contact the U.S. Fish and Wildlife Service Law Enforcement Office at (425) 883-8122, or the FWS's Washington Fish and Wildlife Office at (360) 753-9440.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The FWS recommends the following to the FHWA:

1. Coordinate with the EPA, WDOE, Corps, and members of the LDWG (including, but not limited to the Boeing Company) to ensure that the final design and plans for construction present no unacceptable consequences for planned corrective actions and remedial clean-ups along the South Park reach and lower Duwamish Waterway.
2. Further investigate alternatives that might avoid or reduce the risk of contaminant transport as a result of post-construction channel bed scour in the vicinity of the new and existing bridge piers. Remove all contaminated sediment from within temporary cofferdams. Consider "over-sizing" some or all of the cofferdams to more effectively remove a larger portion of the potentially contaminated sediment.
3. Infiltrate and/or disperse treated stormwater runoff to the fullest extent practicable. Select, site, and design stormwater runoff treatment and flow control facilities so as to minimize direct discharges to fish-bearing waterbodies.

In order for the FWS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the FWS requests notification of the implementation of any conservation recommendations.

## REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request. As provided in 50 CFR section 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

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# APPENDIX A

# FRAMEWORK FOR ASSESSING SEDIMENT IMPACTS (2006)

The general impacts of sedimentation within an aquatic system are well known. When a biologist reviews a Biological Assessment or Biological Evaluation under section 7 of the Endangered Species Act, effects are evaluated based on the data or information provided. In most cases, specific information is not supplied by the action agency, or is not available for the biologist to conduct a thorough review and make that vital link between the project and the effect on listed fishes, specifically bull trout (*Salvelinus confluentus*) and their habitat.

Specific information needed by a biologist is related to the physical and biological effects of sediment in a stream. The physical questions include the following:

1. Will the project increase sediment input into the stream?
2. How much sediment will result and for what duration?
3. How far downstream will the sediment move?

Based on these physical questions, the biological effects to listed fish species can then be determined. The biological questions include the following:

1. What life stage(s) are affected by the sediment input?
2. What levels of sedimentation cause adverse effects?
3. What are the biological effects of sediment on fish and their habitat?

## SEDIMENT CLASSIFICATIONS AND DEFINITIONS

Sediment within a stream can be classified into a variety of different categories: turbidity, suspended sediment, bedload, deposited sediment, and wash load (Waters 1995; Bash et al. 2001). A geomorphologist may classify sediment differently than a fisheries biologist. Sediment category definitions include:

- Turbidity - Optical property of water which results from the suspended and dissolved materials in the water that cause light to be scattered rather than transmitted in straight lines. Turbidity is measured in nephelometric turbidity units (NTUs). Measurements of turbidity can quickly estimate the amount of sediment within a sample of water.

- Suspended sediment - Represents the actual measure of mineral and organic particles transported in the water column. Suspended sediment is measured in mg/l and is an important measure of erosion, and is linked to the transport of nutrients, metals, and industrial and agricultural chemicals through the river system.

- Bedload - Consists of larger particles on the stream bottom that move by sliding, rolling, or saltating along the substrate surface. Bedload is measured in tons/day, or tons/year.
- Deposited sediment - The intermediate sized sediment particles that settle out of the water column in slack or slower moving water. Based on water velocity and turbulence, these intermediate size particles may be suspended sediment or bedload.
- Wash load - Finest particles in the suspended load that are continuously maintained in suspension by the flow turbulence, and thus, significant quantities are not found in the bed.

Suspended sediment, turbidity, and deposited sediment are not mutually exclusive as to particle size, because they will overlap considerably depending on velocity, turbulence, and gradient (MacDonald et al. 1991; Waters 1995). Turbidity cannot always be correlated with suspended solid concentrations due to the effects of size, shape and refractive index of particles (Bash et al. 2001). Turbidity and suspended sediment affect the light available for photosynthesis, visual capability of aquatic animals, gill abrasion and physiological effects to fish. Suspended and deposited sediment affect the habitat available for macroinvertebrates, quality of gravel for fish spawning, and amount of habitat for fish rearing (Waters 1995).

Particle size is also important. Particle diameters less than 6.4 mm are generally defined as "fines" (Bjornn et al. 1977; Bjornn and Reiser 1991; Shepard et al. 1984; Hillman et al. 1987; Chapman 1988; Reiman and McIntyre 1993; Castro and Reckendorf 1995; MBTRT 1998). The quantity of fines within a stream ecosystem is usually associated with the degradation of a fish population (Castro and Reckendorf 1995).

## INFORMATION SOURCES

To determine the overall impact of a project on bull trout, and to specifically understand whether increased sediment may adversely affect bull trout, the biologist will need to review specific information relating to the watershed and stream in which the project is located.

The following documents are important to review:

1. Washington State Conservation Commission's Limiting Factors Analysis. The 1998 Washington State Legislative session produced a number of bills aimed at salmon recovery. One bill was to identify the limiting factors to salmonid populations within watersheds in Washington State. Limiting factors are defined as "conditions that limit the ability of habitat to fully sustain populations of salmon." Limiting factors analyses have been developed for numerous watersheds. The status of the limiting factors analyses for each Water Resource Inventory Area (WRIA) can be found at http://salmon.scc.wa.gov. The Endangered Species Division has final copies of completed documents.

2. Washington Department of Fish and Wildlife's (1998) Salmonid Stock Inventory. The Washington Department of Fish and Wildlife (WDFW) inventoried bull trout and Dolly Varden (*S. malma*) stock status throughout the State. The intent of the inventory is to help identify available information and to guide future restoration planning and implementation. Salmonid Stock Inventory defines the stock within the watershed, life history forms, status and factors affecting production. Spawning distribution and timing for different life stages are provided (migration, spawning, etc.), if known.

3. U.S. Fish and Wildlife Service's (USFWS 1998a) Matrix of Diagnostics/Pathways and Indicators (MPI). The MPI was designed to facilitate and standardize determination of project effects on bull trout. The MPI provides a consistent, logical line of reasoning to aid in determining when and where adverse affects occur and why they occur. The MPI provides levels or values for different habitat indicators to assist the biologist in determining the level of effects or impacts to bull trout from a project and how these impacts may cumulatively change habitat within the watershed.

4. Individual Watershed Resource Publications. Other resources may be available within a watershed that will provide information on habitat, fish species, and recovery and restoration activities being conducted. Local groups can provide valuable information specific to the watershed.

5. Washington State Department of Ecology (WDOE) Water Quality Database. The WDOE has long and short-term water quality data for different streams within the State. Data can be found at www.ecy.wa.gov/programs/eap/fw_riv/rv_main. Clicking on a stream or entering a stream name will provide information on current and past water quality data. This information will be useful for determining the specific turbidity/suspended sediment relationship for that stream (more information below).

6. WDOE Stream Conditions Database. The WDOE has also been collecting benthic macroinvertebrates and physical habitat data to describe conditions under natural and anthropogenic disturbed areas. Data can be found at www.ecy.wa.gov/programs/eap/fw_benth/93-98. Clicking on a stream or entering a stream name will provide habitat and macroinvertebrate data.

7. U.S. Forest Service (USFS) Watershed Analysis Documents. The USFS is required by the Record of Decision for Amendments to the USFS and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl to conduct a watershed analysis for watersheds located on USFS lands. The watershed analysis determines the existing condition of the watershed and makes recommendations for future projects that move the landscape towards desired conditions. Watershed analysis documents are available from individual National Forests or from the Washington Fish and Wildlife Office, Forest Plan Branch.

8. U.S. Fish and Wildlife Service Bull Trout Recovery Plans and Critical Habitat Designations. The draft Bull Trout Recovery Plan for the Coastal-Puget Sound Distinct Population Segment and the final critical habitat designations provide current species status, habitat requirements, and limiting factors for bull trout within specific individual recovery units. These documents are available from the Washington Fish and Wildlife Office and the Service's web page (www.fws.gov).

These documents and websites provide information on stream and watershed conditions as of 2005. This information is critical to understanding baseline conditions and determining future sediment impacts to the aquatic system. A stream has a natural amount of sediment that is transported through the system. This amount of sediment is based on numerous factors: precipitation, topography, geology, streamflow, riparian vegetation, stream geomorphological characteristic, human disturbance, etc (Bash et al. 2001). However, baseline or background levels need to be analyzed with respect to the limiting factors within the watershed.

Different watersheds have different levels of turbidity or suspended sediment. A glaciated stream will have higher sediment levels than a spring-fed stream. Aquatic organisms are adapted to the natural variation in sediment load that occurs seasonally within their stream habitat (ACMRR 1976; Birtwell 1999). Field experiments have found a thirty-fold increase in tolerance of fish to suspended solids between August and November when naturally occurring concentration are expected to be high (Cederholm and Reid 1987). The question at hand is whether additional input of sediment may result in increased bull trout impacts.

Sediment levels in excess of natural amounts can have multiple adverse effects on channel conditions and bull trout (Rhodes et al. 1994). The effect can be fatal at high levels. Low levels may result in sublethal effects such as loss or reduction of foraging capability, reduced growth, reduced resistance to disease, increased stress, and interference with orientation in homing and migration (McLeay et al 1987; Newcombe and McDonald 1991; Bash et al. 2001).

Work-timing windows are usually incorporated into projects to minimize construction impacts to fish. Work-timing windows are time periods when salmonids are at a stage in their life cycle when they are least sensitive to disturbances or are least likely to be present. This is typically outside of the spawning or egg incubating period. Work-timing windows allow the fish to either move away from impacts or to better cope with short term, minimal changes to the habitat and/or decreased water quality. The work-timing windows are usually in July through September. This time may reduce impacts to spawning fish and egg incubating periods, but may exacerbate impacts to juveniles, sub-adults, and adults. Protective mucous secretions are inadequate during the summer months, when natural sediment levels are low in a stream system, and thereby sediment introduction at this time may increase fish risk to stress and disease (Bash et al. 2001).

## BIOLOGICAL EFFECTS OF SEDIMENT ON BULL TROUT

### Classification of Sediment Effects

In the absence of detailed local information on population dynamics and habitat use, any increase in the proportion of fines in substrates should be considered a risk to the productivity of an environment and to the persistence of associated bull trout populations (Rieman and McIntyre 1993). Specific effects of sediment on fish and their habitat can be put into three classes that include (Newcombe and MacDonald 1991; Waters 1995; Bash et al. 2001):

| | |
|---|---|
| Lethal: | Direct mortality to any life stage, reduction in egg-to-fry survival, and loss of spawning or rearing habitat. These effects damage the capacity of the ecosystem to produce fish and future populations. |
| Sublethal: | Reduction in feeding and growth rates, decrease in habitat quality, reduced tolerance to disease and toxicants, respiratory impairment, and physiological stress. While not leading to immediate death, may produce mortalities and population decline over time. |
| Behavioral: | Avoidance and distribution, homing and migration, and foraging and predation. Behavioral effects change the activity patterns or alter the kinds of activity usually associated with an unperturbed environment. Behavior effects may lead to immediate death or population decline or mortality over time. |

Environmental factors affecting sediment impacts on individual fish include duration of exposure, frequency of exposure, toxicity, temperature, life stage of fish, angularity and size of particle, severity/magnitude of pulse, time of occurrence, general condition of biota, and availability of and access to refugia (Bash et al. 2001). Aquatic systems are complex interactive systems, and isolating the effects of sediment on fish populations is difficult (Castro and Reckendorf 1995). Determining which environmental variables act as limiting factors has made it difficult to establish the specific effects of sediment impacts on fish populations (Chapman 1988). For example, excess fines in the spawning gravels may not lead to smaller populations of adults if the amount of juvenile winter habitat limits the number of juveniles that reach adulthood. Often there are multiple independent variables with complex inter-relationships that can influence population size.

The ecological dominance of a given species is often determined by environmental variables. A chronic input of sediment could tip the ecological balance in favor of one species in a mixed salmonid population, or in species communities composed of salmonids and nonsalmonids (Everest et al. 1987). Bull trout have more spatially restrictive biological requirements than other salmonids at both the individual and population levels (USFWS 1998b). Therefore, they are especially vulnerable to environmental changes such as sediment deposition.

Bull trout are apex predators that prey on a variety of species including terrestrial and aquatic insects and fish (Reiman and McIntyre 1993). Fish are common in the diet of individual bull trout that are over 110 millimeters or longer. Large bull trout can feed almost exclusively on fish. Therefore, when analyzing impacts of sediment on bull trout, it is very important to consider other fish species. While sediment may not directly impact bull trout, the increased sediment input may affect the spawning and population levels of Chinook and coho salmon, cutthroat trout, and steelhead, which are potential prey species for bull trout. The following effects of sediment are not just bull trout specific. All salmonids can be affected similarly.

**Direct effects**

Gill trauma

High levels of suspended sediment and turbidity can cause fish mortality by damaging and clogging gills. Fish gills are delicate and easily damaged by abrasive silt particles (Bash et al. 2001). As sediment begins to accumulate in the gill filaments, fish excessively open and close their gills to expunge the silt. If irritation continues, mucus is produced to protect the gill surface, which may impede the circulation of water over the gills and interfere with fish respiration (Bash et al. 2001). Gill flaring or coughing abruptly changes buccal cavity pressure and is a means of clearing the buccal cavity of sediment. Gill sediment accumulation may result when fish become too fatigued to continue clearing particles via the cough reflex (Servizi and Martens 1991).

Spawning, redds, eggs, and alevins

When suspended sediment deposits in a redd, it can reduce water flow, smothering eggs or alevins or impeding fry emergence, depending on the sediment particle sizes of the spawning habitat (Bjornn and Reiser 1991). Sediment particle size determines the pore openings in the redd gravel. With small pore openings, more suspended sediments are deposited and water flow is reduced compared to large pore openings.

Egg survival depends upon a continuous supply of well oxygenated water through the streambed gravels (Cederholm and Reid 1987). Eggs and alevins are generally more susceptible than adults to stress from suspended solids. Accelerated sedimentation can reduce the flow of water and, therefore, oxygen to eggs and alevins which can decrease egg survival, decrease fry emergence rates (Cederholm and Reid 1987; Chapman 1988; Bash et al. 2001), delay development of alevins (Everest et al. 1987), reduce growth and cause premature hatching and emergence (Birtwell 1999). Fry delayed in their timing of emergence are less able to compete for environmental resources than other fish that have undergone normal development and emergence (intra- or interspecific competition) (Everest et al. 1987).

Several studies have documented that fine sediment can reduce the reproductive success of salmonids. Natural egg-to-fry survival of coho salmon, sockeye and kokanee has been measured at 23, 23, and 12 percent, respectively (Slaney et al. 1977). Substrates containing 20 percent fines can reduce emergence success by 30-40 percent (MacDonald et al. 1991). A decrease of 30 percent in mean egg-to-fry survival can be expected to reduce salmonid fry production to extremely low levels (Slaney et al. 1977).

Although bull trout generally have a narrow, specific spawning habitat requirement and therefore, spawn in a small percentage of the stream habitat available to them (MBTRT 1998), they seem to be more tolerant of sedimentation during development and emergence than other salmonids. Survival of bull trout embryos through emergence appears to be unaffected when the percentage of fines comprise up to 30 percent of the streambed. However, at levels above 30 percent, embryo survival through emergence dropped off sharply with survival below 20 percent for substrates with 40 percent fine material (Shepard et al. 1984).

**Indirect effects**

Macroinvertebrates

Macroinvertebrates are a significant food source for salmonids. Turbidity and suspended solids can affect macroinvertebrates in multiple ways through increased invertebrate drift, feeding impacts, respiratory problems, and loss of habitat (Cederholm and Reid 1987). Salmonids favor certain groups of macroinvertebrates, such as mayflies, caddisflies, and stoneflies. These species prefer large substrate particles in riffles and are negatively affected by fine sediment (Everest et al. 1987; Waters 1995).

The effect of light reduction from turbidity has been well documented as increasing invertebrate drift (Waters 1995; Birtwell 1999). This may be a behavioral response associated with the night-active diel drift patterns of macroinvertebrates. While increased turbidity results in increased macroinvertebrate drift, it is thought that the overall invertebrate populations would not fall below the point of severe depletion (Waters 1995).

Increased suspended sediment can abrade the respiratory surface of macroinvertebrates and interfer with food uptake for filter-feeders (Birtwell 1999). Increased suspended sediment levels tend to clog feeding structures and reduce feeding efficiencies, which results in reduced growth rates, increased stress, or death of the invertebrates (Newcombe and MacDonald 1991). Invertebrates living in the substrate are also subject to scouring or abrasion which can damage respiratory organs (Bash et al. 2001).

Benthic invertebrates inhabit the stream bottom. Therefore, any modification of the streambed by deposited sediment will most likely have a profound effect upon the benthic invertebrate community (Waters 1995). Increased sediment can affect macroinvertebrate habitat by filling interstitial space and rendering attachment sites unsuitable. This may cause invertebrates to seek a more favorable habitat (Rosenberg and Snow 1975). The degree to which substrate particles are surrounded by fine material was strongly correlated with macroinvertebrate abundance and composition (Birtwell 1999). At an embeddedness of one-third, insect abundance can decline by about 50 percent, especially for riffle-inhabiting taxa (Waters 1995).

### Feeding Efficiency

Increased turbidity and suspended sediment can affect salmonid feeding rates, reaction distance, and prey selection (Bash et al. 2001). Changes in feeding behavior are primarily related to the reduced visibility in turbid water. Effects on feeding ability are important as salmonids must meet energy demands to compete with other fishes for resources and to avoid predators.

Distance of prey capture and prey capture success both were found to decrease significantly when turbidity was increased (Berg and Northcote 1985). Waters (1995) states that the loss of visual capability, leading to reduced feeding, is one of the major sublethal effects of high suspended sediment. Increases in turbidity was reported to decrease the percentage of prey captured (Bash et al. 2001). At 0 NTUs, 100 percent of the prey items were consumed. At 20 to 60 NTUs, significant delay in the response of fish to prey was observed. At 10 NTUs, fish were frequently unable to capture prey species; at 60 NTUs, only 35 percent of the prey items were captured. Loss of visual capability and capture of prey leads to depressed growth and reproductive capability.

Sigler et al. (1984) found that a reduction in growth occurred in steelhead and coho salmon when turbidity was as little as 25 NTUs. The slower growth was presumed to be from a reduced ability to feed; however, other complex mechanisms, such as the quality of light, may also affect feeding success rates. Redding et al. (1987) found that suspended sediment may inhibit normal feeding activity, as a result of a loss of visual ability or as an indirect consequence of increased stress.

### Habitat Effects

Compared to other salmonids, bull trout have more specific habitat requirements that appear to influence their distribution and abundance (Reiman and McIntyre 1993). All life history stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools. Other habitat characteristics important to bull trout include channel and hydrologic stability, substrate, temperature, and the presence of migration corridors (Reiman and McIntyre 1993).

The physical effects of sediment in streams include degradation of spawning and rearing habitat, simplification and damage to habitat structure and complexity, loss of habitat, and decreased connectivity between habitat (Bash et al. 2001). Biological implications of this habitat damage include underutilization of stream habitat, abandonment of traditional spawning habitat, displacement of fish from their habitat, and avoidance of habitat (Newcombe and Jensen 1996).

As sediment enters a stream, it is transported downstream under normal fluvial processes and deposited in areas of low shear stress (MacDonald and Ritland 1989). These areas are usually behind obstructions, near banks (shallow water) or within interstitial spaces. This episodic filling of successive storage compartments continues in a cascading fashion downstream until the flow drops below the threshold required for movement or all pools have reached their storage capacities (MacDonald and Ritland 1989). As sediment load increases, the stream compensates by geomorphologic changes in increased slope, increased channel width, decreased depths, and decreased flows (Castro and Reckendorf 1995). These processes, in turn, contribute to increased erosion and sediment deposition which further degrade salmonid habitat.

Loss of acceptable habitat and refugia, as well as decreased connectivity between habitat reduces the carrying capacity of streams for salmonids (Bash et al. 2001). In systems lacking adequate number, distribution, and connectivity of habitat, fish may travel longer distances or use less desirable habitat and may encounter a variety of other conditions that can increase biological demands.

The addition of fine sediment (less than 6.4 mm) to natural streams during summer decreased abundance of juvenile Chinook salmon in almost direct proportion to the amount of pool volume lost to fine sediment (Bjornn et al. 1977; Bash et al. 2001). Similarly, the inverse relationship between fine sediment and densities of rearing Chinook salmon indicate how high sediment loads effect important winter habitat (Bjornn et al. 1977). As fine sediments filled the interstitial spaces between the cobble substrate, juvenile Chinook salmon were forced to leave preferred habitat and to utilize cover that may be more susceptible to ice scouring, predation, and decreased food availability (Hillman et al. 1987). Deposition of sediment on substrate may lower winter carrying capacity for bull trout (Shepard et al. 1984). Food production in the form of aquatic invertebrates may also be reduced.

Juvenile bull trout densities are highly influenced by substrate composition (Shepard et al. 1984; Reiman and McIntyre 1993; MBTRT 1998). During the summer, juvenile bull trout hold positions close to the stream bottom and often seek cover within the substrate itself. When streambed substrate contains more than 30 percent fine materials, juvenile bull trout densities drop off sharply (Shepard et al. 1984). Any loss of interstitial space or streambed complexity through the deposition of sediment would result in a loss of summer and winter habitats (MBTRT 1998). The reduction in rearing habitats ultimately reduces the potential number of recruited juveniles and ultimately reduces population numbers (Shepard et al. 1984).

Although fish avoidance in response to increased sediment may be an initial adaptive survival strategy, displacement from cover could be detrimental. The possible consequences of fish moving from preferred habitat to avoid increasing levels of suspended sediment may not be beneficial if displacement is to sub-optimal habitat, where they also become stressed and more vulnerable to predation (Birtwell 1999).

Physiological Effects

Sublethal levels of suspended sediment may cause undue physiological stress to fish, reducing the ability of the fish to perform vital functions (Cederholm and Reid 1987). At the individual fish level, stress can reduce growth, increase disease, and reduce the ability to tolerate additional stress (Bash et al. 2001). At the population level, the effects of stress may include reduced spawning success, increased larval mortality, reduced recruitment to succeeding life stages and, therefore, overall population declines (Bash et al. 2001).

Tolerance to suspended sediment may be the net result of a combination of physical and physiological factors related to oxygen availability and uptake by fish (Servizi and Martens 1991). The energy needed to perform repeated coughing (see Gill trauma section) increases metabolic oxygen demand. Metabolic oxygen demand is related to water temperature. As temperatures increase, so does metabolic oxygen demand, but the concentration of oxygen available in the water decreases. Therefore, fish tolerance of suspended sediment may be primarily related to the capacity of the fish perform work associated with the cough reflex. However, as sediment increases, fish have less capability to do work, and therefore less tolerance for suspended sediment (Serizi and Martens 1991).

Redding et al. (1987) observed higher mortality in young steelhead trout exposed to a combination of suspended sediment (2500 mg/l) and a bacterial pathogen, than when exposed to the bacteria alone. Physiological stress in fishes appears to decrease immunological competence, growth, and reproductive success (Bash et al. 2001).

Table 1 – Severity of effects (SEV).

| | |
|---|---|
| | **Nil Effect** |
| 0 | No behavioral effects |
| | **Behavioral Effects** |
| 1 | Alarm reaction |
| 2 | Abandonment of cover |
| 3 | Avoidance response |
| | **Sublethal Effects** |
| 4 | Short-term reduction in feeding rates; short-term reduction in feeding success |
| 5 | Minor physiological stress; increase in rate of coughing; increased respiration rate |
| 6 | Moderate physiological stress |
| 7 | Moderate habitat degradation; impaired homing |
| 8 | Indications of major physiological stress; long-term reduction in feeding rate and/or feeding success; poor condition |
| | **Lethal & Paralethal Effects** |
| 9 | Reduced growth rate; delayed hatching; reduced fish density |
| 10 | 0-20% mortality; increased predation; moderate to sever habitat degradation |
| 11 | > 20 – 40% mortality |
| 12 | > 40 – 60% mortality |
| 13 | > 60 – 80% mortality |
| 14 | > 80 – 100% mortality |

Behavioral effects

Increased turbidity and suspended sediment may also cause behavior changes in salmonids. Avoidance, distribution, and migration may be affected. Many behavioral effects result from changes in stream habitat as well (see Habitat effects section). As suspended sediment concentration increases, habitat may be lost which results in abandonment and avoidance of preferred habitat. Stream reach emigration is a bioenergetic demand that may affect the growth or reproductive success of the individual fish (Bash et al. 2001). Sediment pulses result in downstream migration of fish, which disrupts social structures, and causes downstream displacement of other fish (McLeay et al 1987; Bash et al. 2001). Loss of territoriality and the breakdown of social structure can lead to secondary effects of decreased growth and feed rates, which may lead to mortality (Berg and Northcote 1985; Bash et al. 2001).

To the contrary, when not motivated by excess sediment, downstream migration by bull trout can provide access to more prey, better protection from avian and terrestrial predators, and alleviate potential intraspecific competition or cannibalism in rearing areas (MBTRT 1998). Benefits of migration from tributary rearing areas to larger rivers or estuaries may be increased growth potential. Increased sedimentation may result in premature or early migration of both juveniles and adults, or avoidance of habitat and migration of nonmigratory resident bull trout. Such migration exposes fish to many new hazards, including passage of sometimes difficult and unpredictable physical barriers, increased vulnerability to predators, exposure to introduced species, exposure to pathogens, and the challenges of new and unfamiliar habitats (MBTRT 1998).

High turbidity can also delay migration back to spawning sites, although turbidity alone does not seem to affect homing. Delays in spawning migration and associated energy expenditure may reduce spawning success and therefore population size (Bash et al. 2001).

## EFFECTS DETERMINATION

The point at which adverse effects to fish occur from a specific project can be difficult to determine without adequate data. There are numerous variables that affect the determination, and for which data may be unavailable. These include project specific sediment input, existing sediment conditions, stream conditions (velocity, depth, etc.) during construction, weather or climate conditions (precipitation, wind, etc.), fish presence or absence (bull trout plus prey species), effectiveness of the best management practices employed, plus many others.

The Washington Fish and Wildlife Office (WFWO) is currently drafting protocol to obtain specific project related sediment data. This protocol will be used to identify project related sediment input during construction, as well as long-term sedimentation that may result after completion of the project (i.e. high-flow events, channel adjustments, etc.). Following the protocol will provide consistent information on project-related sediment input to assist in evaluating effects and quantifying incidental take in biological opinions.

Newcombe and Jensen (1996) provide a basis for determining when a project will be "likely to adversely affect" bull trout. They conducted a literature review of pertinent documents on sediment effects to salmonids and nonsalmonids, and developed a model that calculated the severity of effect (SEV) based on the suspended sediment dose (exposure) and concentration.

A 15-point scale is used to qualitatively rank the effects of sediment on fish (Table 1). Specific SEV levels will be used to determine when a project is "likely to adversely affect" bull trout.

The following procedure will be used:

1. Select either a. or b. below.

    a. Based on water quality monitoring data, determine the amount of sediment and the duration of sediment input into the stream. (Currently not enough data are available to use this step. As more project specific data becomes available this step will be used).

    b. Use State water quality standards. Because action agencies must meet State water quality standards you can use the standard for determining sediment input into the stream. The Washington State water quality standards for turbidity are provided in Table 2.

The State water quality standard allows for a mixing zone downstream of the project site. The point of compliance is based on stream discharge (Table 3).

The water quality standard must be converted from turbidity (NTUs) to suspended solids (mg/l). A ratio of 1:1 to 1:5 has been derived for converting turbidity to suspended solids (Birtwell 1999). Washington Department of Ecology or U.S. Geological Survey data should be used to determine specific turbidity:suspended solid ratios for the stream on which the project will be conducted (see Documents and Background Information section). If site specific ratios can not be determined use worse case ratio of 1:4 or 1:5.

2. Based on the background information gathered, determine what life stage(s) of bull trout will be affected by sedimentation (see Documents and Background Information section). Use Figures 1 through 4 to determine what SEV level will result for the life stage affected by the project.

3. Use Table 4 to determine what ESA determination is made for the life stage affected.

4. If a LAA determination is made, then the rationale for adverse effects is based on the SEV value obtained. The rationale is not just for that specific level (SEV = 6), but includes previous SEVs as well.

5. Table 5 summarizes the project-specific water quality monitoring data received by the Service for individual projects and indicates that, in some cases, adverse effects that rise

to the level of "incidental take" may occur up to at least 600 ft downstream of project locations. Water quality monitoring data can indicate, by analogy, typical levels of sediment impacts for different project types, and can be used to estimate the minimum extent of impact. The data include the distance from the project where water quality sampling occurred and the maximum NTU levels were observed. Additional monitoring data will be incorporated when available.

Table 2 - Turbidity water quality standards for various classes of surface waters in the State of Washington.

| **Washington State Classes for Surface Waters** | **Turbidity Characteristic** |
|---|---|
| Class AA (extraordinary) | Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is ≤ 50 NTU or have > 10 percent increase in turbidity when the background turbidity is > 50 NTU. |
| Class A (excellent) | Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is ≤ 50 NTU or have > 10 percent increase in turbidity when the background turbidity is > 50 NTU |
| Class B (good) | Turbidity shall not exceed 10 NTU over background turbidity when the background turbidity is ≤ 50 NTU or have > 20 percent increase in turbidity when the background turbidity is > 50 NTU |

Table 3 - Turbidity mixing zones for turbidity water quality standards.

| Waterbody Type | Point of Compliance |
|---|---|
| Stream: | |
| ≤ 10 cfs Stream Flow at Time of Construction | 100 ft downstream of activity causing turbidity exceedance |
| >10 cfs up to 100 cfs Stream Flow at Time of Construction | 200 ft downstream of activity causing turbidity exceedance |
| > 100 cfs Stream Flow at Time of Construction | 300 ft downstream of activity causing turbidity exceedance |

Figure 1 - Severity-of-ill-effect scores for juvenile and adult salmonids.

**Juvenile and Adult Salmonids**
**Average severity-of-ill-effect scores**

| Concentration (mg/l) | Hours 1 | Hours 3 | Hours 7 | Days 1 | Days 2 | Days 6 | Weeks 2 | Weeks 7 | Months 4 | Months 11 | Months 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 162755 | 10 | 11 | 11 | 12 | 12 | 13 | 14 | 14 | - | - | - |
| 59874 | 9 | 10 | 10 | 11 | 12 | 12 | 13 | 13 | 14 | - | - |
| 22026 | 8 | 9 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | - |
| 8103 | 8 | 8 | 9 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 |
| 2981 | 7 | 8 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 12 | 13 |
| 1097 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 12 |
| 403 | 5 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 12 |
| 148 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 10 | 11 |
| 55 | 4 | 5 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 9 | 10 |
| 20 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 9 |
| 7 | 3 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 8 | 9 |
| 3 | 2 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 7 | 7 | 8 |
| 1 | 1 | 2 | 2 | 3 | 3 | 4 | 5 | 5 | 6 | 7 | 7 |

Figure 2 - Severity-of-ill-effect scores for adult salmonids.

**Adult Salmonids**
**Average severity-of-ill-effect scores**

| Concentration (mg/l) | Hours | | | Days | | | Weeks | | Months | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 3 | 7 | 1 | 2 | 6 | 2 | 7 | 4 | 11 | 30 |
| 162755 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | - | - | - |
| 59874 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | - |
| 22026 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 |
| 8103 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 13 |
| 2981 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 12 | 13 |
| 1097 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 12 |
| 403 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 11 |
| 148 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 10 |
| 55 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 9 | 9 |
| 20 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 |
| 7 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 8 |
| 3 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 |
| 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 5 | 6 | 6 |

Figure 3 - Severity-of-ill-effect scores for juvenile salmonids.

**Juvenile Salmonids**
**Average severity-of-ill-effect scores**

| Concentration (mg/l) | 1 | 3 | 7 | 1 | 2 | 6 | 2 | 7 | 4 | 11 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hours | | | Days | | | Weeks | | Months | | |
| 162755 | 9 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | - | - | - |
| 59874 | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 14 | 14 | - | - |
| 22026 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | - |
| 8103 | 7 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 13 | 14 |
| 2981 | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 13 |
| 1097 | 6 | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 13 |
| 403 | 5 | 6 | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 11 | 12 |
| 148 | 4 | 5 | 6 | 6 | 7 | 8 | 9 | 9 | 10 | 11 | 11 |
| 55 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 10 | 11 |
| 20 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 10 |
| 7 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | 9 |
| 3 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 | 8 |
| 1 | 1 | 1 | 2 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 8 |

Figure 4 - Severity-of-ill-effect scores for eggs and alevins of salmonids.

**Eggs and Alevins of Salmonids**
**Average severity-of-ill-effect scores**

| Concentration (mg/l) | 1 Hours | 3 Hours | 7 Hours | 1 Days | 2 Days | 6 Days | 2 Weeks | 7 Weeks | 4 Months | 11 Months | 30 Months |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 162755 | 7 | 9 | 10 | 11 | 12 | 13 | 14 | - | - | - | - |
| 59874 | 7 | 8 | 9 | 10 | 12 | 13 | 14 | - | - | - | - |
| 22026 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | - | - | - | - |
| 8103 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | - | - | - |
| 2981 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 14 | - | - | - |
| 1097 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 14 | - | - | - |
| 403 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | - | - |
| 148 | 5 | 6 | 7 | 9 | 10 | 11 | 12 | 13 | 14 | - | - |
| 55 | 5 | 6 | 7 | 8 | 9 | 10 | 12 | 13 | 14 | - | - |
| 20 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | - | - |
| 7 | 4 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | - |
| 3 | 4 | 5 | 6 | 7 | 8 | 10 | 11 | 12 | 13 | 14 | - |
| 1 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 13 | 14 | - |

Table 4 - ESA Effect calls for different bull trout life stages in relation to the duration of effect and severity-of-ill-effect.

| Life Stage | SEV | ESA Effect Call |
|---|---|---|
| Egg/alevin | 1 to 4<br><br>5 to 14 | not applicable - alevins are still in gravel and are not feeding.<br><br>LAA - any stress to egg/alevin reduces survival |
| Juvenile | 1 to 4<br><br>5 to 14 | NLAA<br><br>LAA |
| Subadult and Adult | 1 to 5<br><br>6 to 14 | NLAA<br><br>LAA |

Table 5 - Water quality monitoring data received by the Washington Fish and Wildlife Office showing distance downstream where data were recorded and the maximum magnitude of turbidity observed.

| Project | Distance downstream from project that data were recorded | Distance downstream that State water quality standards are met, or the maximum turbidity levels observed. |
|---|---|---|
| Debris jam removal (SR - 20) | Not provided | Met standard |
| Rock placed in stream (Hoh River emergency bank protection) | 100 ft - 200 ft | Met standard |
| Bridge construction (SR - 90)<br><br>Stated removal of coffer dams and diversion resulted in increased turbidity. | Not provided | Maximum daily magnitude measured: 25 NTUs over standard. |
| River scour protection (SR 12) Contract no. C-6186 | 300 ft and 600 ft | Maximum daily magnitude measured: 9.3 NTUs over standard. |
| Bridge construction | 200 ft | Maximum daily magnitude measured: 169 NTUs. |
| Culvert replacement project not described (SR241) - Contract # 6270 - Sulfur Cr. | 100 ft and 200 ft | Maximum daily magnitude measured: over 30 NTUs. |
| Bank stabilization (Saxon Cr.) | 300 ft | Maximum daily magnitude measured: 35.2 NTUs over standard. |
| Culvert replacement – (Stossel Cr Way.) | Not provided | Maximum daily magnitude measured: 24 NTUs over background. |
| Culvert Replacement – (Stevens Creek) | 178 ft and 576 ft | Maximum daily magnitude measured: 185 NTUs over background. |
| Culvert Replacement – (Sunbeam Creek) | 72 ft and 147 ft | Maximum daily magnitude measured: 454 NTUs over background. |
| Culvert Replacement – (Unnamed Waddell Creek Tributary) | 62 ft | Maximum daily magnitude measured: 600 NTUs over background. |

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## APPENDIX B

## STATUS OF BULL TROUT CRITICAL HABITAT (Rangewide)

This Biological Opinion does not rely on the regulatory definition of "destruction or adverse modification" of critical habitat at 50 CFR 402.02. Instead, we have relied upon the statute and the August 6, 2004, Ninth Circuit Court of Appeals decision in Gifford Pinchot Task Force v. U.S. Fish and Wildlife Service (No. 03-35279) to complete the following analysis with respect to critical habitat.

### Legal Status

The Service published a final critical habitat designation for the coterminous United States population of the bull trout on September 26, 2005 (70 FR 56212); the rule became effective on October 26, 2005. The scope of the designation involved the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments (also considered as interim recovery units). Rangewide, the Service designated 143,218 acres of reservoirs or lakes and 4,813 stream or shoreline miles as bull trout critical habitat (Table 1).

Table 1. Stream/shoreline distance and acres of reservoir or lakes designated as bull trout critical habitat by state.

| | Stream/shoreline Miles | Stream/shoreline Kilometers | Acres | Hectares |
|---|---|---|---|---|
| Idaho | 294 | 474 | 50,627 | 20,488 |
| Montana | 1,058 | 1,703 | 31,916 | 12,916 |
| Oregon | 939 | 1,511 | 27,322 | 11,057 |
| Oregon/Idaho | 17 | 27 | | |
| Washington | 1,519 | 2,445 | 33,353 | 13,497 |
| Washington (marine) | 985 | 1,585 | | |

Although critical habitat has been designated across a wide area, some critical habitat segments were excluded in the final designation based on a careful balancing of the benefits of inclusion versus the benefits of exclusion (see Section 3(5)(A) and Exclusions under Section 4(b)(2) in the final rule). This balancing process resulted in all proposed critical habitat being excluded in 9 proposed critical habitat units: Unit 7 (Odell Lake), Unit 8 (John Day River Basin), Unit 15 (Clearwater River Basin), Unit 16 (Salmon River Basin), Unit 17 (Southwest Idaho River Basins), Unit 18 (Little Lost River), Unit 21 (Upper Columbia River), Unit 24 (Columbia River), and Unit 26 (Jarbidge River Basin). The remaining 20 proposed critical habitat units were designated in the final rule. It is important to note that the exclusion of waterbodies from designated critical habitat does not negate or diminish their importance for bull trout conservation.

## Conservation Role and Description of Critical Habitat

The conservation role of bull trout critical habitat is to support viable core area populations (70 FR 56212). The core areas reflect the metapopulation structure of bull trout and are the closest approximation of a biologically functioning unit for the purposes of recovery planning and risk analyses. Critical habitat units generally encompass one or more core areas and may include foraging, migration, and overwintering (FMO) areas, outside of core areas, that are important to the survival and recovery of bull trout.

Because there are numerous exclusions that reflect land ownership, designated critical habitat is often fragmented and interspersed with excluded stream segments. These individual critical habitat segments are expected to contribute to the ability of the stream to support bull trout within local populations and core areas in each critical habitat unit.

The primary function of individual critical habitat units is to maintain and support core areas which 1) contain bull trout populations with the demographic characteristics needed to ensure their persistence and contain the habitat needed to sustain those characteristics (Rieman and McIntyre 1993); 2) provide for persistence of strong local populations, in part, by providing habitat conditions that encourage movement of migratory fish (Rieman and McIntyre 1993; MBTSG 1998); 3) are large enough to incorporate genetic and phenotypic diversity, but small enough to ensure connectivity between populations (Rieman and McIntyre 1993; Hard 1995; Healey and Prince 1995; MBTSG 1998); and 4) are distributed throughout the historic range of the species to preserve both genetic and phenotypic adaptations (Rieman and McIntyre 1993; Hard 1995; MBTSG 1998; Rieman and Allendorf 2001).

The Olympic Peninsula and Puget Sound critical habitat units are essential to the conservation of amphidromous bull trout, which are unique to the Coastal-Puget Sound bull trout population. These critical habitat units contain nearshore and freshwater habitats, outside of core areas, that are used by bull trout from one or more core areas. These habitats, outside of core areas, contain Primary Constituent Elements (PCEs) that are critical to adult and subadult foraging, overwintering, and migration.

Within the designated critical habitat areas, the PCEs for bull trout are those habitat components that are essential for the primary biological needs of foraging, reproducing, rearing of young, dispersal, genetic exchange, or sheltering. Note that only PCEs 1, 6, 7, and 8 apply to marine nearshore waters identified as critical habitat; and all except PCE 3 apply to FMO habitat identified as critical habitat.

The PCEs are as follows:

(1) Water temperatures that support bull trout use. Bull trout have been documented in streams with temperatures from 32° to 72 °F (0° to 22 °C) but are found more frequently in temperatures ranging from 36° to 59 °F (2° to 15 °C). These temperature ranges may vary depending on bull trout life-history stage and form, geography, elevation, diurnal and seasonal variation, shade, such as that provided by riparian habitat, and local

groundwater influence. Stream reaches with temperatures that preclude bull trout use are specifically excluded from designation.

(2) Complex stream channels with features such as woody debris, side channels, pools, and undercut banks to provide a variety of depths, velocities, and instream structures.

(3) Substrates of sufficient amount, size, and composition to ensure success of egg and embryo overwinter survival, fry emergence, and young-of-the-year and juvenile survival. This should include a minimal amount of fine substrate less than 0.25 inch (0.63 centimeter) in diameter.

(4) A natural hydrograph, including peak, high, low, and base flows within historic ranges or, if regulated, currently operate under a biological opinion that addresses bull trout, or a hydrograph that demonstrates the ability to support bull trout populations by minimizing daily and day-to-day fluctuations and minimizing departures from the natural cycle of flow levels corresponding with seasonal variation.

(5) Springs, seeps, groundwater sources, and subsurface water to contribute to water quality and quantity as a cold water source.

(6) Migratory corridors with minimal physical, biological, or water quality impediments between spawning, rearing, overwintering, and foraging habitats, including intermittent or seasonal barriers induced by high water temperatures or low flows.

(7) An abundant food base including terrestrial organisms of riparian origin, aquatic macroinvertebrates, and forage fish.

(8) Permanent water of sufficient quantity and quality such that normal reproduction, growth, and survival are not inhibited.

Critical habitat includes the stream channels within the designated stream reaches, the shoreline of designated lakes, and the inshore extent of marine nearshore areas, including tidally influenced freshwater heads of estuaries.

In freshwater habitat, critical habitat includes the stream channels within the designated stream reaches, and includes a lateral extent as defined by the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent will be defined by the bankfull elevation. Bankfull elevation is the level at which water begins to leave the channel and move into the floodplain and is reached at a discharge that generally has a recurrence interval of 1 to 2 years on the annual flood series. For designated lakes, the lateral extent of critical habitat is defined by the perimeter of the water body as mapped on standard 1:24,000 scale topographic maps.

In marine habitat, critical habitat includes the inshore extent of marine nearshore areas between mean lower low-water (MLLW) and minus 10 meters (m) mean higher high-water (MHHW), including tidally influenced freshwater heads of estuaries. This refers to the area between the average of all lower low-water heights and all the higher high-water heights of the two daily tidal levels. The offshore extent of critical habitat for marine nearshore areas is based on the extent of the photic zone, which is the layer of water in which organisms are exposed to light. Critical habitat extends offshore to the depth of 33 ft (10 m) relative to the MLLW.

Adjacent stream, lake, and shoreline riparian areas, bluffs, and uplands are not designated as critical habitat. However, it should be recognized that the quality of marine and freshwater habitat along streams, lakes, and shorelines is intrinsically related to the character of these adjacent features, and that human activities that occur outside of the designated critical habitat can have major effects on physical and biological features of the aquatic environment.

Activities that cause adverse effects to critical habitat are evaluated to determine if they are likely to "destroy or adversely modify" critical habitat by altering the PCEs to such an extent that critical habitat would not remain functional to serve the intended conservation role for the species (70 FR 56212, USFWS 2004). The Service's evaluation must be conducted at the scale of the entire critical habitat area designated, unless otherwise stated in the final critical habitat rule (USFWS and NMFS 1998). Therefore, adverse modification of bull trout critical habitat is evaluated at the scale of the final designation, which includes the critical habitat designated for the Klamath River, Columbia River, Coastal-Puget Sound, and Saint Mary-Belly River population segments.

**Current Condition Rangewide**

The condition of bull trout critical habitat varies across its range from poor to good. Although still relatively widely distributed across its historic range, the bull trout occurs in low numbers in many areas, and populations are considered depressed or declining across much of its range (67 FR 71240). This condition reflects the condition of bull trout habitat.

There is widespread agreement in the scientific literature that many factors related to human activities have impacted bull trout and their habitat, and continue to do so. Among the many factors that contribute to degraded PCEs, those which appear to be particularly significant and have resulted in a legacy of degraded habitat conditions are as follows: 1) fragmentation and isolation of local populations due to the proliferation of dams and water diversions that have eliminated habitat, altered water flow and temperature regimes, and impeded migratory movements (Rieman and McIntyre 1993; Dunham and Rieman 1999); 2) degradation of spawning and rearing habitat and upper watershed areas, particularly alterations in sedimentation rates and water temperature, resulting from forest and rangeland practices and intensive development of roads (Fraley and Shepard 1989; MBTSG 1998); 3) the introduction and spread of nonnative fish species, particularly brook trout and lake trout, as a result of fish stocking and degraded habitat conditions, which compete with bull trout for limited resources and, in the case of brook trout, hybridize with bull trout (Leary et al. 1993; Rieman et al. 2006); 4) in the Coastal-Puget Sound region where amphidromous bull trout occur, degradation of mainstem river FMO habitat, and the degradation and loss of marine nearshore foraging and migration habitat due to urban and residential development; and 5) degradation of FMO habitat resulting from reduced prey base, roads, agriculture, development, and dams.

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